# 農事試驗場歐文報告

第一卷第二號

THE

# BULLETIN

OF THE

# IMPERIAL

# CENTRAL

# AGRICULTURAL EXPERIMENT STATION

# JAPAN.

Vol. I. No. 2.

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# On the Formation of Flowers after Frost.

BY

G. DAIKUHARA.

A very singular phenomenon was observed by the writer when he examined, this spring (1906), the mulberry plantations of Fukushima and Gumma Prefectures, that had suffered severely by a late frost, April 30. Five earlier frosts[1] had probably already done some injury. On arriving there on May 8 I noticed that nearly all the young leaf buds had turned brown and were dead, but in many cases at the base of each dead or half injured leaf bud, 4-6 young green panicles had started covered with small flower buds, producing a very singular appearance,[2] so that a new formation of leaf buds but not of flower buds would be expected, especially as the bark was not the least injured by the frost. And further, what was still more remarkable, some very young buds which had not yet opened and therefore were not injured by the frost, showed, on being cut open, that they had

1). The dates, the maximum temperatures of air and soil, and the humidity of the air during the five frosts of April observed at Fukushima observatory are shown in the following table:

| Date. | Minimum temperature of | | Humidity of air at 2 p.m. (%) |
|---|---|---|---|
| | Air. | Soil. | |
| April 1 ... ... ... | −1.2° C | −6.0° C | 28 |
| „ 11 ... ... ... | 1.8° „ | −4.6 „ | 48 |
| „ 12 ... ... ... | −2 7 „ | −7.6 „ | 44 |
| „ 20 ... ... ... | −1.0 „ | −5.6 „ | 28 |
| „ 21 ... ... ... | −0.2 „ | −4.6 „ | 35 |
| „ 30 ... ... ... | −3.2 „ | −9.0 „ | 22 |

2). Old mulberry trees, especially those which are not cut every year, show generally a tendency to form numerous flowers but there are commonly no flowers formed on those trees which are subjected to the annual cutting either from near the surface of the ground or from stumps 2–3 feet above the ground; those of a very poor growth are excepted. Some few varieties, however, show more or less tendency to form flowers even when cut every year.

turned into flower buds and young panicles were found between the young leaves. The photograph taken is reproduced on Plate XIV.

How is this phenomenon to be explained?

Some time ago O. Loew[1] published some articles on the tendency of flowering, in which he pointed out that numerous facts render it very probable that a necessary condition for flower formation is a certain concentration of sugar in the plant juice. Further the removal of a part of the root, a deficiency of nitrogen, dryness of the soil and plenty of sunshine are favorable for flower formation, in that these conditions lead to an increase of sugar concentration. On the other hand, increased moisture of the soil, position in the shade and especially an increase of nitrogen favor much more the leaf formation than the flower formation, either by dilution of the sugar solution or by inducing transformation of sugar into asparagine and protein.

The conclusion at which O. Loew arrived was confirmed a short time afterwards by Hugo Fisher[2] who mentioned however some more cases in which flower formation was induced by increase of the sugar concentration. He pointed out, e.g., that potatoe plants in a dry season with plenty of sun-shine produce more abundant flowers and less tubers than in moderately moist seasons. Further, cherry branches attacked by the fungus *Exoaxus* yield more leaves and less or no flowers compared with healthy branches of the same tree. Wires tied around the branch induce this branch in the following years to earlier and more abundant flowering. Then the sugar produced in the leaves can not be so abundantly transported to the trunk and roots and therefore reaches a higher concentration in the branches. *Iberis umbellata* just at the starting of flowering time placed behind blue or yellow solutions will produce more abundant flowers in the yellow light, on account of carbon assimilation being favored. Fisher mentions as a rule: nutrition by light and air (carbon assimilation) favors flower formation, while nutrition by soil and water favors leaf formation (protein formation, absorption of N, S, & P).

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1). Flora, 1905, p. 124 and 324 (Supplement).

2). Flora, 1905, p 478. See also W. Benecke, Bot. Zeitg., 1906, April.

In the light of these facts, the above described phenomenon on the mulberry plants can be explained as follows :

In the 1st place, the development of the young leaves had drawn considerably on the stock of reserve protein in the neighboring parts of the bark and the remaining relatively larger amount of reserve starch yielded now a solution richer in sugar, and

In the 2nd place, the migration of the juice into the growing leaves, requiring a certain proportion of sugar, was stopped by their death and thus the concentration of the sugar in the sap was increased ; and

In the 3rd place, the dry weather before and after the frost favored more or less the flower formation by the concentration of the cell sap.

Travelling four weeks later in another prefecture (Ibaraki) I also noticed the damage to mulberry trees by the same frost (April 30) but in this case not only flowers developed from the base of the killed young leaves but in many cases the flowers were much more numerous in the *upper* part of the stem than in the *lower*, which is just the contrary of the normal phenomenon. The number of panicles[1] observed on some of such stems are shown in the following table :

| No. of branches from the top of stalk. | Number of panicles observed on the branches of six stalks. | | | | | |
|---|---|---|---|---|---|---|
| | A. | B. | C. | D. | E. | F. |
| No. 1 | 3 | 1 | ..... | 2 | ..... | ..... |
| „ 2 | 3 | 2 | ..... | ..... | ..... | ..... |
| „ 3 | 4 | ..... | 0 | ..... | 5 | ..... |
| „ 4 | 2 | 2 | 0 | 4 | 4 | 2 |
| „ 5 | 4 | 1(2) | 2 | ..... | 2 | 4 |
| „ 6 | 4 | ..... | 2 | 5 | 4 | 3 |
| „ 7 | 3 | 3 | 3 | 2 | 3 | 3 |
| „ 8 | 3 | ..... | 3 | ..... | 5 | ..... |
| „ 9 | 1 | 3 | ..... | 3 | 5 | 1(2) |
| „ 10 | 3 | 2 | 2 | ..... | 2 | 2 |
| „ 11 | 4 | 0 | 3 | ..... | 1 | 0 |

Dotted lines shows dead buds.

1). Nearly all panicles were staminated.

2). No leaves on these buds, only flowers.

| No. of branches from the top of stalk. | Number of panicles observed on the branches of six stalks. | | | | | |
|---|---|---|---|---|---|---|
| | A. | B. | C. | D. | E. | F. |
| No. 12 | 3 | 0 | ..... | 3 | 2 | 0 |
| „ 13 | 5 | 3 | 0 | 0 | 3 | 0 |
| „ 14 | 2 | 0 | 4 | 0 | 2 | ..... |
| „ 15 | ..... | 1 | ..... | ..... | ..... | 2 |
| „ 16 | 3 | 1 | 1 | ..... | 0 | 1 |
| „ 17 | 1 | 1 | ..... | 2 | 0 | 0 |
| „ 18 | ..... | 0 | ..... | 0 | ..... | 0 |
| „ 19 | ..... | 0 | ..... | ..... | ..... | ..... |
| „ 20 | 1 | 1 | 1 | ..... | 0 | ..... |
| „ 21 | 0 | 0 | ..... | ..... | ..... | 0 |
| „ 22 | ..... | | 0 | 2 | ..... | 0 |
| „ 23 | 0 | | ..... | ..... | 0 | |
| „ 24 | ..... | | ..... | ..... | ..... | |
| „ 25 | 1 | | 1 | ..... | ..... | |
| „ 26 | 2 | | 0 | 0 | ..... | |
| „ 27 | 0 | | ..... | 1 | 1 | |
| „ 28 | 0 | | 0 | ..... | ..... | |
| „ 29 | ..... | | ..... | ..... | 0 | |
| „ 30 | 0 | | ..... | ..... | 0 | |
| „ 31 | 1 | | ..... | 0 | 0 | |
| „ 32 | 0 | | 0 | 0 | 0 | |
| „ 33 | 0 | | 0 | 2 | 0 | |
| „ 34 | 1 | | 1 | 0 | 0 | |
| „ 35 | | | ..... | | | |
| „ 36 | | | 0 | | | |
| „ 37 | | | 0 | | | |
| „ 38 | | | 0 | | | |
| „ 39 | | | 0 | | | |

Dotted lines show dead buds.

Further, numerous buds were injured to such an extent that neither leaf nor flower developed from them, although at the base of the bud the bark proved still green and healthy. Furthermore in those cases in which the upper part of the stem was completely killed, it was observed that the branch development later on was most vigorous just below the dead

portion of the branch. Moreover in those cases in which the leaf-buds were merely injured by the frost without being killed, the number of panicles appearing at the base of these shoots was much larger than in those cases where less injury had been done, and finally no panicles at all appeared at the base of such branches which had developed after the frost from closed buds.—See Plate XIV and XV.

Finally it may be mentioned that I have tested for oxdizing enzymes in leaves entirely killed by frost and turned brown, and found oxydase and peroxydase to be absent, while catalase was plentiful. The watar extract of frozen leaves was precipitated with alcohol, the precipitate dissolved in water and tested again for oxydases also with negative result. The behavior of oxydases towards freezing requires further observations. Further I have scraped off a considerable part of the living bark of such branches which had developed flowers from the base of killed leaf-buds and tested it in the usual way for cane sugar and glucose. It was thus observed that cane sugar was present in much larger quantities than glucose.

## EXPLANATION OF PLATES.

### PLATE XIV.

Three stems bearing 3–5 panicles on the base of every bud after frost.

### PLATE XV.

Fig. (a) and (b). Half injured branches bearing 6–7 panicles on their bases.

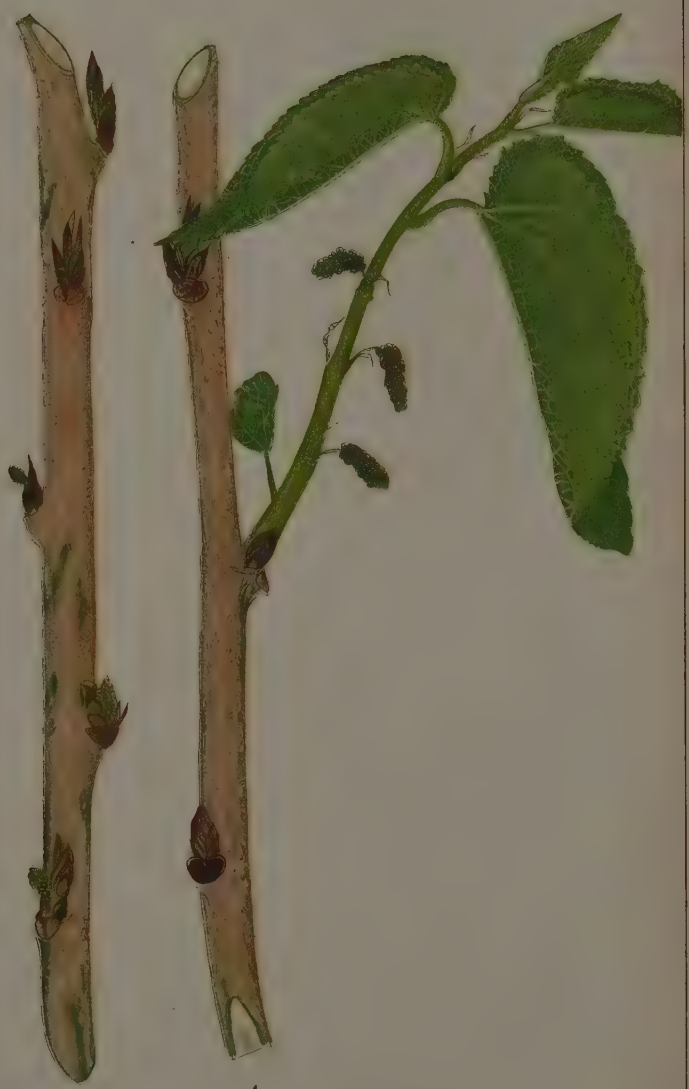
Fig. (c). A normal new branch coming out after frost and bearing no panicles.

### PLATE XVI.

Fig. (A). A new branch bearing three panicles developing from the accessory bud after frost.

Fig. (B). A stem on which all buds were severely damaged and developing no leaves until after four weeks, but producing many panicles from the base of the killed buds.

a
b
c



B. A.

# On the Behavior of Nitrate in Paddy Soils.

BY

G. DAIKUHARA AND T. IMASEKI.

A great many manuring experiments carried out by different authors prove that under certain conditions nitrate nitrogen is superior to ammonia nitrogen, while under other conditions the reverse is true. It is to be regretted, however, that the different conditions, as nature of soil, its chemical composition and the character of the manure whether acidic or alkaline or neutral, have not always been stated, since this knowledge would have assisted much in recognising certain regularities.

For those tropical and subtropical countries, in which agricultural crops are raised in paddy soils or swamps, the question is also of vital importance, which of the two sources of nitrogen would be the more favorable. The conditions in the paddy soil for nitrification and denitrification are very different from those in the dry land soil. In the first place, the transformation of ammonia into nitrite by the nitroso-bacterium is very much depressed not only on account of less air penetrating into the soil, but also on account of much organic matter, which is by no means oxidized as easily as in dry land, and which according to Winogradsky, depresses the action of the nitrite-microbium; but also for the nitrate-microbium the conditions are very unfavorable, since its action is very much depressed by traces of ammonia. Loehnis[1] however declared that only in the form of carbonate, ammonia is injurious for the nitrate-microbium not in the form of neutral salts. The paddy soil for rice culture in Japan has always been manured chiefly with excrements, fish manure, oil cakes, and frequently green manure; superphosphate was applied occasionally as a mere supplement to

1). Chem. Ztg. Repertorium 1905, 1, 5.

those manures. These conditions being favorable for denitrification might lead to much loss, if nitrate were applied as a part of the nitrogen manure. Until recently however no experiments with plants cultivated in swamps have been made. It was Prof. M. Nagaoka[1] who first carried out a number of careful experiments with plants cultivated by Japanese farmers in swamps as viz. rice, arrowhead (*Sagittaria sagittaefolia*) and *Juncus effusus*. *Sagittaria* bulbs are used as food and *Juncus* is used for the manufacture of rugs. The Plants manured with nitrate remained pale in color and small in size. With rice the yield of the nitrate plants was only in one case a little above that of the control plants, in most cases, however, far below; in one case, where the soil received no lime and the ratio of 150 Kg N p. ha., the yield of the nitrate plants fell to about 2% of that of ammonia plants.

With *Juncus* the yield of the nitrate plants varied from 4,7–66% of the ammonia plants provided with equal doses of nitrogen. For *Sagittaria* the result was still more unfavorable. It is very remarkable that with *Juncus* the harvest of the nitrate plants diminished gradually with the increased applications of the nitrate.

Some experiments[2] carried out by one of us (Daikuhara) with rice plants in sand culture showed that the availability of nitrate is 42% of that of ammonia nitrogen. The average ratio for the manurial value of ammonia nitrogen to that of nitrate nitrogen calculated from different results of experiments carried out in our central and branch Stations during the last few years is 100 : 47.

As to the reason why the paddy plants cannot utilize nitrate nitrogen so well as ammonia nitrogen, Nagaoka[3] has proposed the two following factors:

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1). Bull. College of Agric., Imp. University, Tokyo, Vol. VI., No. 3.

2). This Bulletin Vol. I., No. 1.

3). Nagaoka has also ascribed the pale yellowish color of the nitrate plants to the physiological influence of accumulated nitrate, but according to our observations the pale yellowish color appears in the first period of growth, 2–3 weeks after the application of nitrate, and recovers afterwards. It is very probable, therefore, due to the poisonous action of nitrite formed by the reducing action of certain bacteria.

1. Paddy plants do not accumulate a sufficient quantity of sugar in the leaves to convert all of the nitric acid absorbed into protein.

2. In paddy soils, denitrification and also formation of poisonous nitrites may take place.

As to the first we have instituted some tests. It might be assumed that an injurious accumulation of nitrate may take place in the leaves of the rice plants manured with nitrate but as to this there is no positive proof yet. But the result of our analysis shows practically no difference not only between the leaves of paddy and dry land rice, but also between those of the paddy rice applied with ammonium sulphate and sodium nitrate as shown in the following tables :

A. Sugar content in the leaves of the paddy and dry land rice.

| Kind of rice plant. | Name of varieties. | Period of Growth. | Glucose % | Cane sugar % | Total sugar % |
|---|---|---|---|---|---|
| Paddy rice | Shin-shu ... | Before flowering | 1.19 | 0.48 | 1.67 |
| | | Milky repening | 2.04 | 0.74 | 2.78 |
| | | Yellow ripening | 1.94 | 0.24 | 2.18 |
| | Suga-ippon. | Young leaves | 0.89 | 0.48 | 1.37 |
| | | Before flowering | 1.21 | 0.64 | 1.85 |
| | | Milky ripening | 2.48 | 1.15 | 3.63 |
| | | Yellow ripening | 2.47 | 0.55 | 3.02 |
| Dry land rice | Oiran ... | Before flowering | 1.19 | 0.56 | 1.75 |
| | | Milky ripening | 2.02 | 0.85 | 2.87 |
| | | Yellow ripening | 2.16 | 0.56 | 2.72 |
| | Kiushu ... | Young leaves | 0.89 | 0.52 | 1.41 |
| | | Before flowering | 1.29 | 0.69 | 1.98 |
| | | Milky ripening | 2.00 | 1.10 | 3.10 |
| | | Yellow ripening | 2.59 | 0.46 | 3.05 |

B. Sugar content in the leaves of paddy rice with different manures.

| Kind of Manures. | Period of Growth. | Glucose % | Cane sugar % | Total sugar % |
|---|---|---|---|---|
| Ammonium sulphate | Young leaves | 0.99 | 0.33 | 1.32 |
| | Before flowering | 1.60 | 0 56 | 2 16 |
| | Milky ripening | 1.56 | 0.66 | 2.22 |
| Sodium Nitrate | Young leaves | 0.87 | 0 47 | 1.34 |
| | Before flowering | 1.35 | 0.50 | 1.85 |
| | Milky ripening | 1.36 | 0.75 | 2.11 |

Thus we see that the first assumption by Nagaoka was not justified.

Some tests were made by Nagaoka with regard to the second cause, rendering however further observations desirable and we have therefore further studied the behavior of swamp plants towards nitrate, being certainly of considerable theoritical and practical importance.

With the denitrifying organisms in a wide sense the following groups may be distinguished after Jensen[1]:

"1. Reduktion von Nitraten zu Nitriten und Ammoniak (Salpeterreduktion).

2. Reduktion von Nitraten zu Nitriten und niederiegeren, gasförmigen Stickstoff-Sauerstoffverbindungen ($N_2O$ und NO).

3. Reduction von Nitraten und Nitriten unter Abspaltung elementaren Stickstoffes (Denitrifikation im engeren und eigentlichen Sinne).

4. Umbildung des Salpeterstickstoffes in organische Verbindungen (Salpeterassimilation).

5. Freiwerden von Stickstoff bei der Faeulnis organischer Stickstoff verbindungen."

Denitrification will proceed much more energetically in moist land than in dry land and also nitrates will be reduced to nitrites more

1). Lafer, Handb. d. Techn. mycologie Band III., S. 182.

energetically by peculiar bacteria of the paddy soil, and these nitrites may persist for a time before they are further reduced to ammonia. Certain bacteria reduce nitrates very quickly to ammonia so that the intermediary step, the formation of nitrites, can not be recognized. Certain other bacteria, however, produce considerable quantities of nitrites from nitrates. Nitrites however show a strong poisonous character, since they act very powerfully on the amido-groups and hence will also attack the amido-groups of proteins and thus kill the living protoplasm.

In order to decide whether denitrification takes place extensively in paddy soil the following experiments were made:

## LABORATORY EXPERIMENT. I.[1]

One hundred g of soil were placed in an Erlenmeyer's flask of 300 cc. capacity and added 150 cc. of a solution containing 2 g of sodium nitrate and 0,2 g of $K_2HPO_4$ which liquid kept the soil covered in a thin layer. A humy soil from our experimental field, a sandy loam soil from Kinai Branch Station and a heavy clayey soil from Kaga Province served for this experiment. The experiment was started on March 23, 1905; the flasks were shaken every day and tested from time to time for nitrite by the reaction of Griess. The room temperature during this experiment was 16–26°C. After 24 hours a very decisive reaction for nitrite was already observed with the humus soil, much less than in the sandy soil, and only a trace was found in the clayey soil. After 5 resp. 6 days, the maximum point of formation of nitrite (0,003 resp. 0,002% $KNO_2$)[2] was attained in the humy and the sandy soil, whereupon the nitrite decreased, disappearing after 3 resp. 4 weeks, much nitrate still remaining in the solution. In the clayey soil, however, the reduction of nitrate was very slow and the maximum point was reached (0,01% nitrite) after 4 weeks; a little nitrite was still present even after 5 months. From the start of the experiment ammonia was occasionally tested for and reactions obtained in all of the

1). Laboratory experiment I, II, III, IV, V and VI (d) were carried out by G. Daikuhara, and Laboratory expt. VI (a), (b) and (c) by T. Imaseki.

2). By colorimetric determination.

flasks, especially with the sandy soil, somewhat less so with the clayey soil and still weaker in the humus soil. With the humus and sandy soils a little sodium acetate was added to accelerate the bacterial action, after the nitrite reaction had disappeared. Thus again a gradual increase of the nitrite was observed and finally it reached a concentration of 0,1% resp. 0,05% nitrite 12 days after that addition, much foam being developed. No ammonia was observed in this case.

Further to ascertain whether the reduction of nitrate was due to bacteria, the mixture of soil and the nitrate solution mentioned above, was sterilized with steam, with chloroform and with mercuric chloride. Occasional testing for nitrite showed the absense of nitrite even after several weeks. This proves clearly that the reduction of nitrate in soils in the paddy state certainly is due to the action of denitrifying organisms.

## LABORATORY EXPERIMENT. II.

Since in Japan much organic manure is commonly used in the paddy field, it is of vital importance to observe the influence of organic matter upon the reduction of nitrate in the paddy state. 150 cc. of the following nitrate solution was mixed with 100 g of air dry soil and kept at a temperature of 30–32°C. It was found that all the nitrate was reduced entirely after 48 hours.

| | |
|---|---|
| Na-acetate (or glycerine) ... ... ... ... ... ... ... ... ... ... | 0.5 % |
| $NaNO_3$ ... ... ... ... ... ... ... ... ... ... ... ... ... | 0.2 % |
| $K_2HPO_4$ ... ... ... ... ... ... ... ... ... ... ... ... ... | 0.2 % |
| $MgSO_4+7H_2O$ ... ... ... ... ... ... ... ... ... ... ... ... | 0.02% |

On April 15, 1905, 100 g of the three different soils above mentioned were mixed with the same nitrate solution containing glycerine and kept at room temperature (13–26°C). The occasional tests for nitrite and ammonia gave the following results:

(a). Test for nitrite.[1)]

| From the start. | Humy clay soil. | Sandy loam soil. | Clay soil. |
|---|---|---|---|
| After 3 days | 0.0013% $KNO_2$ | 0.004% $KNO_2$ | 0.002% $KNO_2$ |
| „ 4 „ | 0.0010% „ | 0.005% „ | 0.003% „ |
| „ 6 „ | 0.0033% „ | 0.005% „ | 0.007% „ |
| „ 9 „ | trace | trace | 0.0008% „ |
| „ 12 „ | 0 | 0 | trace |

(b). Test for ammonia.

| From the start. | Humy clay soil. | Sandy loam soil. | Clay soil. |
|---|---|---|---|
| After 3 days | little | moderate | moderate. |
| „ 4 „ | „ | „ | „ |
| „ 6 „ | „ | „ | „ |
| „ 9 „ | „ | „ | „ |
| „ 12 „ | trace | trace | little |

The above result shows that by the presence of a certain amount of organic matter the reduction of nitrate in the paddy soil is much accelerated and all the nitrate added (0,2%) reduced entirely after 9–12 days even at room temperature in spring and after 2 days when kept at 30–32°C.

## LABORATORY EXPERIMENT. III.

Former experiments carried out by various investigators show that fresh stable manure favors denitrification more than a well rotten one, but in regard to fresh and rotten oil cakes no special observations seem to have been made, therefore we have made the following experiment:

(a). On Aug. 14, 1905, 100 g of soil from our Station at Nishigahara 2 g of rape cake (1) and 5 cc. of glycerine (2) and 150 cc. of the nitrate

1). The amount of nitrite was also here approximately determined colorimetrically by Griess test. A standard solution of pure $KNO_2$ served for the comparison.

solution of the following composition and kept at room temperature (20–32°C) with occasional testing for nitrite and nitrate :

$NaNO_3$ ... ... ... ... ... ... ... ... ... 2.00 g
$K_2HPO_4$ ... ... ... ... ... ... ... ... 0.20 g
$MgSO_4+7H_2O$ ... ... ... ... ... ... ... 0.02 g
} dissolved in 150 cc. $H_2O$.

After 24 hours a stronger nitrite reaction was observed in (1) than in (2) (0,05% resp. 0,005% nitrite as $KNO_2$). The maximum amount of nitrite was attained after 3 days with (1) and after 5 days with (2) but after 4 resp. 7 weeks all the nitrate was reduced. Thus we see that fresh rape cake favors denitrification much more than glycerine.

(b). Some rape cake and soy been cake were left to putrefy in a warm place with a moderate supply of water and after 2 months rottening, samples were dried and finely pulverized. Two g of each, fresh cakes and the same amount of dry matter of the rotten cakes were mixed respectively with 100 g of air dry soil and 150 cc. of the following nitrate solution, and kept at 25°C.

$NaNO_3$ ... ... ... ... ... ... ... ... ... 1.75 g
$K_2HPO_4$ ... ... ... ... ... ... ... ... 0.50 g
$MgSO_4+7H_2O$ ... ... ... ... ... ... ... 0.05 g
} dissolved in 150 cc. of $H_2O$.

The tests showed that with fresh rape cake all the nitrate was reduced after 2 weeks, but with rotten cake much nitrate was still present even after 10 weeks. With soy been cake which is poorer in carbohydrates and richer in protein the difference was much smaller and the nitrate was reduced entirely in the case of fresh and rotten cake after 10 and 12 days respectively.

Thus we see that the fresh rape cakes favor denitrification much more than the rotten.

## LABORATORY EXPERIMENT. IV.

To see the effect of inoculation of denitrifying organisms, pure cultured, into the soil in the paddy state, the following 3 organisms were selected :

a). Bact. denitrificans I.
b). „ „ II.[1)]
c). „ nitrovorum.

One hundred g of soil from our Experiment Station were kept in an Erlenmeyer's flask of ca. 300 cc. capacity with 100 cc. of nitrate solution as in Expt. III, (a). After repeated sterilization the denitrifying organisms were inoculated on Aug. 16, 1905, and kept at room temperature. Of the supernatant solutions small doses were withdrawn from time to time with a sterilized pipette, and tested for nitrate, nitrite and ammonia with the following results:

(a). Bact. denitrificans I. Much nitrite was found after 24 hours and after 6 days the amount of nitrite reached the maximum (0,125% $KNO_2$). But even after 2 months later both nitrate and nitrite were still present.

(b). Bact. denitrificans II. The nitrite reaction was observed after 2 days from the start and after 9 days this reaction showed the maximum. All the nitrate and nitrite were reduced after 13 days from the start.

(c). Bact. nitrovorum. Nitrite was observed also after two days, the maximum point of the nitrite reaction after 6 days, and the disappearance of both nitrate and nitrite after 16 days from the start.

A moderate ammonia reaction was obtained in each mixture after 3 days, (a) yielded much, (b) and (c) a weak ammoniacal reaction after 5–10 days, and still a moderate reaction after 2 weeks.

Further with the flask (a) much pasty film was noticed on the surface of the soil, but with flasks (b) and (c) this was not the case; the liquids became gradually turbid and of a light reddish-brown color.

## LABORATORY EXPERIMENT. V.

To observe the influence of starch, compost, straw and rape cake upon the reduction of nitrate in paddy soil and to determine the loss of nitrogen by denitrification the following experiment was made.

On Sept. 18, 1905, 28 Erlenmeyer's flasks of ca. 300 cc. capacity were

1). These two organisms were isolated from the soil in the field of this Station by S. Machida. Burri and Stutzer were the first to isolate denitrifying bacteria in pure culture.

filled with 200 g of humy soil from Nishigahara containing 30.53% $H_2O$ and mixed with the following salts,[1] dissolved in 250 cc. $H_2O$, and organic manures.[1] As general nutrients 0,5 g di-potassium-phosphate and 0,05 g magnesium sulphate were added to each flask and kept at room temperature (15–26°C).

| | | |
|---|---|---|
| I. | Ammonium sulphate[2] | 1.25 g. |
| II. | Sodium nitrate | „ „ |
| III. | Ammonium nitrate | „ „ |
| IV. | Sodium nitrate | „ „ |
| | Starch | 2.00 „ |
| V. | Sodium nitrate | 1.25 „ |
| | Compost well rotten (a) sterilized | 6.00 „ |
| VI. | Sodium nitrate | 1.25 „ |
| | Compost well rotten (b) not sterilized | 6.00 „ |
| VII. | Sodium nitrate | 1.25 „ |
| | Rape cake | 2.00 „ |
| VIII. | Sodium nitrate | 1.25 „ |
| | Straw in powder | 6.00 „ |
| IX. | Starch | 2.00 „ |
| X. | Compost well rotten (a) sterilized | 6.00 „ |
| XI. | Compost well rotten (b) sterilized | 6.00 „ |
| XII. | Rape cake | 2.00 „ |
| XIII. | Straw in powder | 6.00 „ |
| XIV. | Control | — |

The experiment was carried out in duplicate. While one series served for occasional testing the other served for the final determination. It was observed that flasks containing starch, rape cake and straw showed the strongest reaction for nitrate, and with the starch flask after 10 days from start,

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1). Nitrogenous manures subjected to this experiment contained the following percentage of N:

| | | |
|---|---|---|
| a) | Ammonium sulphate | 20.50 % N |
| b) | Ammonium nitrate | 34.80 „ „ |
| c) | Sodium nitrate | 15.55 „ „ |
| d) | Rape cake | 5.70 „ „ |
| e) | Compost well rotten | 1.41 „ „ |
| f) | Straw | 0.57 „ „ |

2). One g of precipitated magnesium carbonate was added to neutralize the acidity of sulfuric acid.

with the rape cake flask after two weeks and with the straw flask after four weeks, all the nitrate aud nitrite were reduced. In the other flasks, however, to which the nitrate was added much nitrate was still present after 6 weeks and in the ammonium sulphate flask also strong reactions for nitrate and nitrite were noticed after three weeks. With Compost flasks (a) and (b) moderately strong nitrite reactions were observed after 2–3 days from the start but the reaction decreased gradually.

The flasks for the final determinations were kept for 45 days with frequent shaking until the nitrite reaction had entirely disappeared. 100 cc. of supernatent clear solution were withdrawn from each flask to determine the soluble nitrogenous compounds, and the remainder in the flask was evaporated to dryness after adding a little sulphuric acid. The total nitrogen, nitric and ammoniacal nitrogen were determined as usual with the following results :

| No. of Flasks. | Total air dry soil. | In 100 parts of air dry soil. | | | In 100 part of the supernatent solution | | Total amount of | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total N. | A'monia N. | Nitric N. | A'monia N. | Nitric N. | Total N. g | A'monia N. g | Nitric N. g |
| I. | 144.4 | 0.456 | 0 098 | 0.005 | 0 043 | 0.004 | 0.705 | 0.184 | 0.011 |
| II. | 147.9 | 0.403 | 0.034 | 0.082 | 0.003 | 0.072 | 0.671 | 0.053 | 0.193 |
| III. | 147.0 | 0.495 | 0.053 | 0.094 | 6.043 | 0.072 | 0.843 | 0.120 | 0.210 |
| IV. | 142.3 | 0.311 | 0.015 | 0 | 0.004 | 0 | 0.447 | 0.025 | 0 |
| V. | 153.3 | 0 443 | 0.010 | 0.075 | 0.003 | 0.068 | 0.750 | 0.017 | 0.183 |
| VI. | 151.4 | 0.439 | 0.005 | 0.071 | 0.002 | 0.068 | 0.735 | 0.010 | 0.175 |
| VII. | 147.6 | 0.381 | 0 025 | trace | 0.006 | trace | 0.568 | 0.043 | 0 |
| VIII. | 152.9 | 0.348 | 0.005 | 0 | 0.001 | 0 | 0.533 | 0.009 | 0 |
| IX. | 143.0 | 0.307 | 0.020 | 0 | 0 001 | 0 | 0.440 | 0.030 | 0 |
| X. | 148.5 | 0.401 | 0.025 | 0 | 0.003 | 0 | 0.598 | 0.038 | 0 |
| XI. | 152.0 | 0.395 | 0.007 | trace | 0.003 | trace | 0.603 | 0.012 | 0 |
| XII. | 147.5 | 0.377 | 0.015 | 0 | 0.005 | 0 | 0.561 | 0.026 | 0 |
| XIII. | 153.5 | 0.340 | 0.004 | 0 | 0 002 | 0 | 0.524 | 0.007 | 0 |
| XIV. | 145.7 | 0.322 | 0.008 | 0.024 | 0.001 | 0.008 | 0.478 | 0.013 | 0.043 |

From the above figures the loss of nitrogen by the reduction of nitrate was calculated with the result shown in the following tables :

| No. of flasks. | Kind of Manures applied. | Remaining amount of soluble N applied. | Amount of soluble N applied. | Percentage of soluble N remaining. | Loss of soluble N applied. |
|---|---|---|---|---|---|
| I. | $(NH_4)_2SO_4$ | 0.227 g. | 0.256 | 88.7 % | 11.3 % |
| II. | $NaNO_3$ | 0.193 „ | 0.194 | 99.5 „ | 0.5 „ |
| III. | $NH_4NO_3$ | 0.365 „ | 0.435 | 83.9 „ | 16.1 „ |
| IV. | $NaNO_3$ + starch | 0.007 „ | 0.194 | 3.6 „ | 96.4 „ |
| V. | „ + compost a) | 0.152 „ | 0.194 | 78.3 „ | 21.7 „ |
| VI. | „ + „ b) | 0.135 „ | 0.194 | 68.6 „ | 31.4 „ |
| VII. | $NaNO_3$ + rape cake | 0.007 „ | 0.194 | 3.6 „ | 96.4 „ |
| VIII. | „ + straw | 0.009 „ | 0.194 | 4.6 „ | 95.4 „ |

This result confirms the observations made by occasional testing as above stated and clearly shows that the starch, rape cake and straw very much favor denitrification in the paddy soil, while well rotten compost especially when sterilized has far less influence upon denitrification. But little loss of nitrogen took place in flask II to which nitrate alone was applied, perhaps by the accidental absense of the denitrifying microbes proper.

## LABORATORY EXPERIMENT VI.

To observe whether nitrate formation and denitrification[1] take place in the dry land state, the following experiments were carried out.

### A. Dry land top soil.

One hundred g of the following three samples of soil were placed in Erlenmeyer's flasks of ca. 300 cc. capacity with 2 g of sodium nitrate in solution and kept in a moderately dry condition, and in control flasks the same amount of distilled water was applied :

1). Nitrite formation is frequently the first step of denitrification with loss of nitrogen. In certain cases however the nitrite may be completely reduced to ammonia.

1). Humy soil of a field, from Nishigahara.
2). Clay soil from Kaga province.
3). Alluvial sandy loam soil from Arakawa, near Tokyo.

The experiment was begun April 11, 1905, and lasted 50 days, every day a portion of the contents of each flask was withdrawn to test for nitrite. The room temperature was 17–25°C. During 12 days from the start slight reaction for nitrite was observed in the soil (1) and (2) and then the reaction disappeared. In the soil (3) no trace of nitrite was found through the whole period. Thus we see that little or no nitrite formation takes place in the top soil of the dry land state, especially in the sandy soil and when nitrate alone was applied.

## B. Top and Sub-soil in dry land state.

The same soils as in Experiment (A) just described served also for this experiment. They yielded the following chemical and physical data :

| | (1) Humy soil. | (2) Clay soil. | (3) Sandy loam soil. |
|---|---|---|---|
| Hygroscopic water ... ... ... | 12.53 | 1.81 | 2.90 |
| Loss by ignition... ... ... ... | 16.23 | 4.09 | 5.11 |
| Nitrogen ... ... ... ... ... | 0.35 | 0.22 | 0.19 |
| Weight of 100 cc. in loose state ... | 60.40 | 93.50 | 98.25 |
| Weight of 100 cc. in compact state. | 105.55 | 146.50 | 150.15 |
| Absorptive power for $H_2O$ in loose state ... | 106.67 | 49.77 | 48.62 |
| Absorptive power for $H_2O$ in compost state. | 70.25 | 31.81 | 31.28 |

450, 550 and 600 g of these soils resp. were mixed with 4 g of sodium nitrate in a moderate concentration and put in glass cylinders of 3,6 cm. diametre and 36 cm. height open at both ends, the upper half of the soil in a loose condition and the lower half in a compact condition, the lower end of the cylinder being closed with linen smeared with melted paraffin Besides, the cylinders were covered with black paper, sun-light being allowed to reach only the surface of the soils.

The experiment was begun April 12, 1905, and every 2 days in the first period and every 5 days in the later, a portion was withdrawn from the upper and lower layers and tested for nitrate, nitrite and ammonia with the following result:

(1). In the humy soil to which sodium nitrate was added a little nitrite was observed after 2 weeks, increasing a little afterwards, and the reaction was always stronger in the sub-soil than in the top-soil. The reaction for ammonia was observed after one week and was always stronger in the top-soil.

In the control case, however, no nitrite was found through the whole period; after one month a trace of ammonia and after 50 days a trace of nitrate was observed.

(2). In the clay soil to which sodium nitrate was added, a little nitrite was observed after 2 days from the start, the reaction in the sub-soil increasing gradually, reaching the maximum after 2 weeks and remaining the same through the whole period, while in the top-soil no further increase was noticed. Much ammonia was found after two days from the start, the reaction of which was always stronger in the top-soil, just as with the humy soil (1). In the control case, neither nitrate nor nitrite was formed through the whole period, but a trace of ammonia was found after one month, a little more in the top-soil than in the sub-soil.

(3). In the sandy loam to which sodium nitrate was added, a trace of nitrite was observed in the sub-soil after 3 days from start, and the reaction increasing gradually, reached the maximum after 2 weeks, while in the top-soil only a slight reaction for nitrite was observed after 2 weeks. With regard to ammonia, only a trace of it was found after one week which remained constant through the whole period. In the control case, neither nitrate, nor nitrite was found through the whole period and not even a trace of ammonia was found.

The second experiment was carried out with the same soil and cylinders for a longer period viz. five months (June 26—October 28, 1905), the result of which exactly coincided with that of the former experiment above stated. Thus we see that denitrification takes place more or less in the

sub-soil in dry land state, while in the top-soil when kept in a loose condition almost no reduction of nitrate occurs if nitrate alone is applied to the field.

(C). The dry land state with application of some organic substance.

In order to determine the influence of the presence of some organic matter in the soil in dry land state upon denitrification, the following experiment was made with the three soils mentioned below:

1). Humy top-soil from a field of Nishigahara.
2). Clayey sub-soil „ „ „
3). Alluvial sand soil from Arakawa.

The cylinders of the diametre of 4 cm. and of the height of 55 cm. open at both ends, were filled with each soil in the air dry state, upper layer of 25 cm. deep in loose condition and lower layer of 30 cm. deep in compact condition. The soils of the first series were mixed with a solution of sodium nitrate and those for the second series with the same nitrate solution and starch, the ratio of both the nitrate and starch to the soil being 1 : 100. The soils were kept moderately moist and the lower open end of the cylinder was covered with filter paper and linnen and kept air tight with melted paraffin. The sides of the cylinders were covered with black paper.

The experiment was begun Oct. 5, 1905, and was finished Nov. 24, during the first period of which every two days, and later on every 10 days, a portion of the upper and lower layers of the soil was taken out by boring and tested for nitrate, nitrite and ammonia with the following result:

(1). In the humy top-soil to which both the nitrate and starch were applied, much nitrate was present in the upper layer during the whole period, while in the lower layer the nitrate decreased gradually and after 20 days only a trace of it was observed. The soil to which nitrate alone was applied showed a strong reaction for nitrate in both upper and lower layers until the end of the experiment. As to nitrite a trace of it was found in the lower layer during the first period in all cylinders which received nitrate and the reaction disappeared after 12 days in the cylinder to which the nitrate solution alone was applied, while in the cylinder to which both nitrate and

starch were applied the reaction became evident gradually, reaching the maximum after 10 days and then it gradually diminished to a trace after 20 days from start.

(2). In the clayey sub-soil a trace of nitrite was observed in the lower layer of all cylinders except that of the control case, and no further increase of nitrite was noticed in the cylinder to which nitrate alone was applied, while in the cylinder with nitrate and starch the reaction increased gradually reaching the maximum after three weeks from the start and afterwards decreasing gradually but showing the reaction until the end of the experiment.

(3). In the sandy soil with nitrate and starch the nitrate decreased remarkably after 10 days from the start in both upper and lower layers of the soil and after 20 days all the nitrate was reduced, while in the soil with nitrate alone, the nitrate reaction remained intense through the whole period. With nitrite there was no reaction in the control soil and the soil with nitrate alone, while in the soil with nitrate and starch a trace in the upper layer and much of it in the lower layer of soil were observed after 2–3 days from the start, reaching the maximum after 10 days and then decreasing gradually again.

The above results show that in the soil of the dry land state there is hardly any nitrite formation if the nitrate alone is applied. When, however, some organic matter is applied together with the nitrate some reduction will take place, especially in the sub-soil, where the access of air is insufficient, even all the nitrate here will eventually be reduced.

### (D). Comparison of the effect of some organic manures upon the formation of nitrite and denitrification.

In order further to compare the effects of different organic matters, such as starch, rape cake, compost and straw, upon the degree of denitrification in the dry state of land, the following experiment was carried out:

Ten glass flasks of ca. I litre capacity with greased stoppers were filled with 700 g of fine humy soil from Nishigahara containing 19,15% of hygroscopic water. 150 cc. of a solution containing 3.5 g of $NaNO_3$, 2 g of

$K_2HPO_4$ and 0,3 $MgSO_4$ were added to the flasks No. I–V, and the same amount of a solution containing only 2 g $K_2HPO_4$ and 0.3 g $MgSO_4$ without nitrate to the flasks No. VI–X, after mixing the soil thoroughly with the organic matters[1] mentioned:

| | | |
|---|---|---|
| I. | $NaNO_3$ | 3·5 g. |
| II. | $NaNO_3$ | 3·5 ,, |
| | Starch | 5.0 ,, |
| III. | $NaNO_3$ | 3·5 ,, |
| | Compost, well rotten | 21.0 ,, |
| IV. | $NaNO_3$ | 3·5 ,, |
| | Rape cake | 5.0 ,, |
| V. | $NaNO_3$ | 3·5 ,, |
| | Straw | 10.0 ,, |
| VI. | Starch (Control (a)) | 5.0 ,, |
| VII. | Compost well rotten (Control (b)) | 21.0 ,, |
| VIII. | Rape cake (Control (c)) | 5.0 ,, |
| IX. | Straw (Control (d)) | 10.0 ,, |
| X. | ..... (Control (e)) | — |

The experiment was begun Sept. 5, 1905, and every 10 days a certain portion was withdrawn from each vessel, the same amount of water added and tested for nitrite in the filtrate. After 10 days much nitrite was observed in the flasks II and IV, the amount of which as potassium salt approximately determined 0.35% resp. 0.088% $KNO_2$. In flask III only a little nitrite and in all other flasks (except II and IV) only a trace or none of it was observed. After one month in all the flasks only traces of nitrite could be found.

The result shows that in top-soil of "dry" land only certain organic matters, such as starch or rape cake, favor nitrite formation to some extent, but well rotten compost and straw do not.[2]

Increase of moisture will lead to an increase of nitrite and loss of nitrogen; water was added after 33 days from the start at the ratio of 10 cc.

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1). The contents of N in the nitrate and organic manures are the same as in Lab. Expt. V.

2). Stoklasa (Z. Landw. Vers. Wes. in Oesterreich, 1906, p. 844.) observed in Austrian soils serving for culture of sugar beets also denitrification did not take place to such an extent that it could be proved analytically.

$H_2O$ to every 100 g original soil, thus keeping the soil in just a moderately moist condition. After 10 days nitrate reactions were obtained in the flasks II, IV and V. After two months from start the soil was dried after acidulating with a little $H_2SO_4$ and the total N, ammonia N and nitric N determined.

| No. of flasks. | Kind of Manures. | In 100 pts dry soil. | | | N in total dry soil (g). | | |
|---|---|---|---|---|---|---|---|
| | | Total N. | Amm. N. | Nitric N. | Total N. | Amm. N. | Nitr. N. |
| I. | $NaNO_3$ | 0.452 | 0.005 | 0.102 | 2.558 | 0.028 | 0.577 |
| II. | $NaNO_3$+ starch | 0.397 | 0.005 | 0.018 | 2.145 | 0 028 | 0.102 |
| III. | $NaNO_3$+ compost | 0.456 | 0.022 | 0.100 | 2.581 | 0.125 | 0.566 |
| IV. | $NaNO_3$+ rape cake | 0.477 | 0.038 | 0.082 | 2.683 | 0.215 | 0.464 |
| V. | $NaNO_3$+ straw | 0.432 | 0.016 | 0.082 | 2.445 | 0.091 | 0.464 |
| VI. | starch | 0.372 | trace | 0.006 | 2.105 | — | 0.034 |
| VII. | compost | 0.382 | 0.005 | 0.011 | 2.162 | 0.028 | 0.062 |
| VIII. | rape cake | 0.401 | 0.016 | 0.027 | 2.269 | 0.091 | 0.153 |
| IX. | straw | 0.354 | 0.011 | 0.027 | 2.003 | 0.062 | 0.153 |
| X. | ..... | 0.368 | trace | 0.004 | 2.083 | — | 0.023 |

From these figures the loss of nitrogen was calculated.

| No. of flasks. | Kind of manures. | Soluble N applied (g). | Loss of N by denitrification. | |
|---|---|---|---|---|
| | | | g | % |
| I. | $NaNO_3$ | 0.544 | 0.069 | 12.7 |
| II. | $NaNO_3$ + starch | 0.544 | 0.504 | 92.6 |
| III. | $NaNO_3$ + compost | 0.544 | 0.125 | 23.0 |
| IV. | $NaNO_3$ + rape cake | 0,544 | 0.130 | 23.9 |
| V. | $NaNO_3$ + Straw | 0.544 | 0.102 | 18.8 |

These results show that when common dry land top-soil becomes sufficiently moist, as by continuous rains, the presence of an easily putrefying organic matter favors denitrification to a considerable degree.[1]

## VEGETATION EXPERIMENT I.[2]

In order to ascertain the effect of the formation of nitrite and denitrification upon vegetation, the following experiments were made: Six zinc pots of ca. 30 cm. in diametre were filled with 15 Kg of humy soil from Nishigahara and six with alluvial soil from Arakawa. The following manures were applied per pot (in duplicate):

(A). $(NH_4)_2SO_4$ ... 5.0 g
$Na_2HPO_4$ ... 5.0 „
$K_2SO_4$ ... 5.0 „

(B). $NaNO_3$ .. 6.7 „ (N in equivalent to $(NH_4)_2SO_4$)
$Na_2HPO_4$ ... 5.0 „
$K_2SO_4$ ... 5.0 „

1). A considerable degree of denitrification was observed by Hugo Fisher after moderately liming the soil, but the amount of moisture was not stated.

2). All vegetation experiments were carried out by G. Daikuhara.

(C). $NaNO_3$... ... ... ... ... ... ... ... 6.7 g.
$Na_2HPO_4$ ... ... ... ... ... ... ... 5·7 „
Glycerine ... ... ... ... ... ... ... 10,0 cc.

Five young paddy rice plants (*var. Sekitori*) equal in size were trans-planted in each pot on July 5, 1905, and kept in paddy state. The plants in pot (A) was normal while those in pot (B) and (C), showed a yellowish green color in the first period of growth and much foam gathered on the surface of the soil especially in pot (C). After two weeks, however, the plants in pot (B) and (C) again acquired a green color but not the deep green as observed in pot (A).

The following table shows the result of observations on July 25 and on Sept. 5, 1905 :

A. Soil from Nishigahara.

| Kind of Manures. | Length of plants (cm). | | | | Number of stalks. | | | |
|---|---|---|---|---|---|---|---|---|
| | July 25 | | Sept. 5 | | July 25 | | Sept. 5 | |
| | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. |
| $(NH_4)_2SO_4$ | 74·3<br>72.1 | 73.2 | 109.1<br>104.5 | 106.8 | 27<br>33 | 30 | 61<br>58 | 60 |
| $NaNO_3$ | 61.2<br>62,1 | 61.7 | 107 5<br>101.5 | 104.5 | 22<br>22 | 22 | 45<br>46 | 46 |
| $NaNO_3$+ Glycerine | 56.1<br>56.1 | 56.1 | 89.4<br>94.2 | 91.8 | 17<br>17 | 17 | 20<br>20 | 20 |

B. Soil from Arakawa.

| Kind of Manures. | Length of plants (cm). | | | | Number of stalks. | | | |
|---|---|---|---|---|---|---|---|---|
| | July 25 | | Sept. 5 | | July 25 | | Sept. 5 | |
| | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. |
| $(NH_4)_2SO_4$ | 75.8<br>69.1 | 72.5 | 104.9<br>102.1 | 103.5 | 26<br>32 | 29 | 54<br>55 | 55 |
| $NaNO_3$ | 60.6<br>59.2 | 60.0 | 108.4<br>100.9 | 104.7 | 19<br>15 | 17 | 34<br>31 | 33 |
| $NaNO_3$+ Glycerine | 51.5<br>48.5 | 50.0 | 88.0<br>85.0 | 86.5 | 12<br>15 | 14 | 13<br>17 | 15 |

A photograph taken Sept. 2, 1905, and reproduced on Plate XVII shows clearly the differences in development. The plants were cut Oct. 25, 1905, and weighed in the air dry state with the following result:

A. Soil from Nishigahara.

| Kind of Manures. | Weight of Grains (g). | | Weight of Straw (g). | | Total Yield (g). | | Ratio of Total Yield. |
|---|---|---|---|---|---|---|---|
| | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. | |
| $(NH_4)_2SO_4$ | 67.13<br>55.50 | 61,31 | 129.38<br>127.50 | 128.44 | 196.50<br>183.00 | 189.75 | 100 |
| $NaNO_3$ | 57.75<br>55.88 | 56.81 | 85.50<br>90.38 | 87.94 | 143.25<br>146.25 | 144.75 | 76 |
| $NaNO_3$+ Glycerine | 25.50<br>27.00 | 26.25 | 37.50<br>38.25 | 37.88 | 63.00<br>65.25 | 64.13 | 34 |

B. Soil from Arakawa.

| Kind of Manures. | Weight of Grains (g). | | Weight of Straw (g). | | Total Yield (g). | | Ratio of Total Yield. |
|---|---|---|---|---|---|---|---|
| | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. | |
| $(NH_4)_2SO_4$ | 64.13<br>69.37 | 66.75 | 114.00<br>112.50 | 113.25 | 178.13<br>181.88 | 180.00 | 100 |
| $NaNO_3$ | 38.63<br>33.75 | 36.19 | 70.88<br>63.00 | 66.94 | 109.50<br>96.75 | 103.13 | 57 |
| $NaNO_3$ + Glycerine | 18.75<br>16.88 | 17.81 | 22.13<br>22.13 | 22.13 | 40.88<br>39.00 | 39.94 | 22 |

This result coincides exactly with that of the laboratory experiments stated above and shows that glycerine favors denitrification in paddy soil very much. The yellowish color of plants during the first period of growth is most probably due to the poisonous action of nitrite formed by the reduction of nitrate.

## VEGETATION EXPERIMENT II.

36 zinc pots of ca. 25 cm. in diameter were filled with 11 Kg of humy soil from Nishigahara and the following manures applied, 3 pots serving for each trial.

| No. of pots. | Kind of Manures. | Amount of Manures applied p. pot. |
|---|---|---|
| I. | $(NH_4)_2SO_4$ ... ... ... ... ... | 5.0 g. |
| II. | $NaNO_3$ ... ... ... ... ... ... | 6.6 „ |
| III. | $(NH_4)_2SO_4$ ... ... ... ... ... | 2.5 „ |
| | $NaNO_3$ ... ... ... ... ... | 3.3 „ |
| IV. | $NaNO_3$ ... ... ... ... ... | 6.6 „ |
| | Starch ... ... ... ... ... ... | 10.0 „ |

| No of pots. | Kind of Manures. | Amount of Manures applied p. pot. |
|---|---|---|
| V. | $NaNO_3$ ... ... ... ... ... | 6.6 g. |
| | Compost (a) sterilized[1] | 30.0 „ |
| VI. | $NaNO_3$ ... ... ... ... ... | 6.6 „ |
| | Compost (b) not sterilized... ... | 30.0 „ |
| VII. | $NaNO_3$ ... ... ... ... ... | 6.6 „ |
| | Rape cake ... ... ... ... ... | 10.0 „ |
| VIII. | Starch ... ... ... ... ... ... | 10.0 „ |
| IX. | Compost (a) sterilized ... ... ... | 30.0 „ |
| X. | Compost (b) not sterilized ... ... | 30.0 „ |
| XI. | Rape cake ... ... ... ... ... | 10.0 „ |
| XII. | Control ... ... ... ... ... ... | — |

As general manure 5 g of $Na_2HPO_4$ and of $K_2SO_4$ per pot were applied. Ten young paddy rice plants of equal size were transplanted into each pot on Sept. 24,[2] 1905, all pots were kept in the glass house until Nov. 20 and were then removed to a green house kept at 15–30°C. but even here the seeds did not ripen, probably on account of the development of numerous young shoots. The following observations were made Oct. 10 and Feb. 19 when the plants were cut.

1), The compost used in this experiment was well rotten.

2). The transplanting by some obstacle took place later than was desirable.

| No. of pots. | Kind of Manures. | Average length of plants (cm.). | | Average No. of stalks on Feb. 19. |
|---|---|---|---|---|
| | | Oct. 10. | Feb. 19. | |
| I. | $(NH_4)_2SO_4$ ... ... | 34.0 | 66.7 | 32 |
| II. | $NaNO_3$ ... ... ... | 30.3 | 59.9 | 19 |
| III. | $(NH_4)_2SO_4+NaNO_3$.. | 32.7 | 61.7 | 27 |
| IV. | $NaNO_3$ + starch ... | 27.0 | 55.3 | 19 |
| V. | $NaNO_3$ + compost (a). | 30.3 | 58.4 | 22 |
| VI. | $NaNO_3$ + compost (b). | 31.5 | 55.0 | 20 |
| VII. | $NaNO_3$ + rape cake ... | 31.2 | 54.3 | 22 |
| VIII. | Starch only ... ... | 28.2 | 50.7 | 17 |
| IX. | Compost (a) only ... | 27.9 | 52.0 | 17 |
| X. | Compost (b) only ... | 29.1 | 53.6 | 15 |
| XI. | Rape cake... ... ... | 30.9 | 55.5 | 21 |
| XII. | Control ... ... ... | 29.1 | 52.1 | 15 |

Plants in the nitrate pots showed the yellowish green color of the young growing leaves especially in those which received organic manures together with nitrate. The tests showed always much more nitrate (at least more than 3 times as much) in the yellowish leaves than in the normally green ones grown with $(NH_4)_2SO_4$ as a manure. But nitrate could not be observed by Griess' test in the yellowish green leaves.

The photograph taken Feb. 19, 1906, and reproduced on plate XVIII shows clearly the differences of growth. The plants weighed in the air dry state gave the following result:

| No. of pots. | Kind of Manures. | Average weight p. pot in air dry state (g). | | | Gain of yield p. pot by soluble N.[1] | |
|---|---|---|---|---|---|---|
| | | Grain(empty). | Straw. | Total. | g | Ratio. |
| I. | $(NH_4)_2SO_4$ ..... | 2.570 | 54.430 | 57.00 | 31.50 | 100 |
| II. | $NaNO_3$..... | 1.485 | 30.015 | 31.50 | 6.00 | 19 |
| III. | $(NH_4)_2SO_4+NaNO_3$.. | 2.170 | 40.210 | 42.38 | 16.88 | 54 |

1). The gain of N by soluble N-salts was calculated by subtracting the yield of control pot from those of pot I, II, and III, the yields of VIII, IX, X and XI from those of IV, V, VI and VII respectively.

| No. of pots. | Kind of Manures. | Average weight p. pot in air dry state (g). | | | Grain of yield p. pot by soluble N.[1] | |
|---|---|---|---|---|---|---|
| | | Grain (empty) | Straw. | Total. | g | Total. |
| IV. | $NaNO_3$+Starch ... | 1.690 | 23.060 | 24.75 | 1.50 | 5 |
| V. | $NaNO_3$+Compost (a) | 2.560 | 25.940 | 28.50 | 6.00 | 19 |
| VI. | $NaNO_3$+Compost (b) | 1.690 | 23.810 | 25.50 | 4.12 | 14 |
| VII. | $NaNO_3$+Rape cake.. | 1.913 | 32.587 | 34.50 | 2.50 | 8 |
| VIII. | Starch only ... ... | 0.980 | 22.270 | 23.25 | — | — |
| IX. | Compost (a) only ... | 1.307 | 21.193 | 22.50 | — | — |
| X. | Compost (b) only ... | 1.190 | 20.190 | 21.38 | — | — |
| XI. | Rape cake only ... | 1.987 | 30.013 | 32.00 | — | — |
| XII. | Control ... ... ... | 1.263 | 24.237 | 25.50 | — | — |

The amounts of the total nitrogen in the air dry samples (after Kjeldahl determined), the gain of nitrogen by the application of ammonia and nitrate N were as follows:

| No. of pots. | Kind of Manures. | Content of total N. | | Gain of N p. pot by soluble N. | |
|---|---|---|---|---|---|
| | | % | g | g | Ratio. |
| I. | $(NH_4)_2SO_4$ ... ... | 0.711 | 0.405 | 0.209 | 100 |
| II. | $NaNO_3$ ... ... ... | 0.782 | 0.246 | 0.050 | 24 |
| III. | $(NH_4)_2SO_4$+$NaNO_3$.. | 0.743 | 0.315 | 0.119 | 57 |
| IV. | $NaNO_3$+Starch ... | 0.743 | 0.184 | 0.018 | 9 |
| V. | $NaNO_3$+Compost (a) | 0.705 | 0.201 | 0.070 | 33 |
| VI. | $NaNO_3$+Compost (b) | 0.662 | 0.169 | 0.044 | 21 |
| VII. | $NaNO_3$+Rape cake .. | 0.716 | 0.247 | 0.019 | 9 |
| VIII. | Starch only ... ... | 0.713 | 0.166 | — | — |
| IX. | Compost (a) only ... | 0.583 | 0.131 | — | — |
| X. | Compost (b) only ... | 0.585 | 0.125 | — | — |
| XI. | Rape cake only ... | 0.712 | 0.228 | — | — |
| XII. | Control ... ... ... | 0.768 | 0.196 | — | — |

These results show that the efficiency of nitrate nitrogen for the paddy rice is very unsatisfactory and that the simultaneous application of certain organic matters depresses the yield still further. Well rotten compost exerts a less depressing influence than fresh rape cake.

## VEGETATION EXPERIMENT III.

In order to compare, now, dry land with paddy field in regard to the effect of their different degree of denitrification, the following experiment with buckwheat was made: 36 zinc pots of ca. 25 cm. in diameter were filled with 14 Kg humy soil from Nishigahara. The kind and the amount of manures applied were the same as in the vegetation experiment II. 31 seeds of buckwheat were sown Aug. 27, 1905, and 2 weeks after germination the young plants were reduced to 25 per pot all of equal size. The average height of plants measured Oct. 1 was as follows:

| No. of pots. | Kind of Manures. | Average length of plants. |
|---|---|---|
| I. | $(NH_4)_2SO_4$ ... ... ... ... ... ... | 70.3 cm. |
| II. | $NaNO_3$... ... ... ... ... ... ... | 70.0 „ |
| III. | $(NH_4)_2SO_4 + NaNO_3$ ... ... ... ... | 71.5 „ |
| IV. | $NaNO_3$ + Starch ... ... ... ... | 73.0 „ |
| V. | $NaNO_3$ + Compost (a) ... ... ... | 72.4 „ |
| VI. | $NaNO_3$ + Compost (b) ... ... ... | 76.4 „ |
| VII. | $NaNO_3$ + Rape cake ... ... ... ... | 74.8 „ |
| VIII. | Starch only... ... ... ... ... ... | 60.6 „ |
| IX. | Compost (a) only ... ... ... ... | 63.0 „ |
| X. | Compost (b) only ... ... ... ... | 64.8 „ |
| XI. | Rape cake only ... ... ... ... ... | 70.7 „ |
| XII. | Control... ... ... ... ... ... ... | 60.9 „ |

The plants were cut Oct. 25 and weighed in the air dry state with the following result:

| No. of pots. | Kind of Manures. | Weight of seeds (g). | | Weight of stalks (g). | | Total yield (g). | |
|---|---|---|---|---|---|---|---|
| | | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. |
| I. | $(NH_4)_2SO_4$ | a) 28.88<br>b) 22.13<br>c) 24.38 | 25.13 | 15.38<br>14.25<br>15.75 | 15.13 | 44.26<br>36.38<br>40.13 | 40.26 |
| II. | $NaNO_3$ | a) 25.88<br>b) 27.01<br>c) 26.63 | 26.51 | 16.50<br>16.13<br>16.13 | 16.25 | 42.38<br>43.14<br>42.76 | 42.76 |
| III. | $(NH_4)_2SO_4$+ $NaNO_3$ | a) 27.76<br>b) 26.25<br>c) 27.01 | 27.00 | 17.25<br>15.38<br>17.25 | 16.63 | 45.01<br>41.63<br>44.26 | 43.63 |
| IV. | $NaNO_3$+ Starch | a) 18.73<br>b) 20.25<br>c) 21.76 | 20.26 | 13.50<br>15.38<br>14.63 | 14.50 | 32.25<br>35.63<br>36.39 | 34.76 |
| V. | $NaNO_3$+ Compost (a) | a) 26.25<br>b) 27.75<br>c) 24.75 | 26.25 | 17.63<br>21.38<br>19.13 | 19.38 | 43.88<br>49.13<br>43.88 | 45.63 |
| VI. | $NaNO_3$+ Compost (b) | a) 21.76<br>b) 21.38<br>c) 24.76 | 22.63 | 16.88<br>17.63<br>18.38 | 17.63 | 38.64<br>39.01<br>43.14 | 40.26 |
| VII. | $NaNO_3$+ Rape cake | a) 27.00<br>b) 28 51<br>c) 27.01 | 27.50 | 18.00<br>18.00<br>17.25 | 17.75 | 45.50<br>46.51<br>44.26 | 45.25 |
| VIII. | Starch only | a) 8.26<br>b) 9.01<br>c) 9.00 | 8.75 | 8.25<br>7.88<br>7.88 | 8.00 | 16.51<br>16.89<br>16.88 | 16.75 |

| No. of pots. | Kind of Manures. | Weight of seeds (g). | | Weight of stalks (g). | | Total yield (g). | |
|---|---|---|---|---|---|---|---|
| | | p. pot. | Average. | p. pot. | Average. | p. pot. | Average. |
| IX. | Compost (a) only | a) 12.01<br>b) 12.38<br>c) 10.88 | 11.76 | 10.13<br>10.88<br>10.13 | 10.38 | 22.14<br>23.26<br>21.01 | 22.14 |
| X. | Compost (b) only | a) 13.88<br>b) 12.00<br>c) 12.38 | 12.75 | 11.25<br>10.88<br>11.25 | 11.13 | 25.13<br>22.88<br>23.63 | 23.88 |
| XI. | Rape cake only | a) 23.25<br>b) 21.00<br>c) 21.00 | 21.75 | 13.88<br>12.38<br>13.88 | 13.38 | 37.13<br>33.38<br>34.88 | 35.13 |
| XII. | Control | a) 12.01<br>b) 11.63<br>c) 12.00 | 11.88 | 9.75<br>10.13<br>10.13 | 10.00 | 21.76<br>21.76<br>22.13 | 21.88 |

To observe the effect of the several organic manures upon denitrification more clearly, a calculation was made by subtracting the yield of pot XII from those of I, II and III, and from the yields of IV, V, VI, VII, those of VIII, IX X and XI respectively with the following result:

| No. of pots. | Kind of Manures. | Surplus yield by soluble N-salts. | | | |
|---|---|---|---|---|---|
| | | Seeds. | | Total yield. | |
| | | g | Ratio. | g | Ratio. |
| I. | $(NH_4)_2SO_4$ ..... | 13.25 | 90 | 18.38 | 88 |
| II. | $NaNO_3$..... | 14.63 | 100 | 20.88 | 100 |
| III. | $(NH_4)_2SO_4 + NaNO_3$.. | 15.12 | 103 | 21.75 | 104 |
| IV. | $NaNO_3$ + Starch ..... | 11.51 | 78 | 18.01 | 86 |
| V. | $NaNO_3$ + Compost (a) | 14.49 | 99 | 23.49 | 112 |
| VI. | $NaNO_3$ + Compost (b) | 9.89 | 67 | 16.38 | 78 |
| VII. | $NaNO_3$ + Rape cake.. | 5.75 | 39 | 10.12 | 48 |

This result shows again that the well rotten compost when sterilized has no depressing effect upon the efficiency of nitrate-N, while when not sterilized it depresses the yield very much, owing certainly to the importation of denitrifying organisms into the soil. The efficiency of nitrate-N is also much depressed by the simultaneous application of rape cake.

## CONCLUSIONS.

(1). When nitrate is applied to the paddy soil it is reduced to some extent first to nitrite and then to ammonia and to elementary N, the loss of which varies according to the species of denitrifying organisms and the amount of soluble organic compounds present originally in the soil.

(2). When nitrate is applied to the paddy soil together with much organic matter in easily available form for microbes such as glycerine, Na-acetate, starch, fresh oil cakes and straw, it is destroyed extensively by denitrification, the most part of its nitrogen being lost as free N, while only a certain portion of it remains in the soil, being partly assimilated by microbes and partly absorbed as ammonia by the soil or plants.

(3). The question why nitrate is not a favorable manure for plants grown in paddy land can be answered as follows:

a). The *loss of N by denitrification* is larger in paddy soil than in dry land.

b). More of the *poisonous nitrites* are formed there than in dry land.[1]

c). *Loss of nitrate* takes place easily by the system of *irrigation*, practiced with paddy plants, being inevitable in the farmers practice.

(4). Dry land surface soil when no organic manures are applied along with nitrate,[2] does not favor denitrification nor nitrite-formation while in the subsoil reduction occurs to some extent. In very moist conditions, however, as in the rainy season and especially when much organic manure is applied along with nitrate, some denitrification takes place even in top-

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1). Young rice plants placed in a potassium nitrite solution of 0,1% died after 5 days.

2). According to *Ampola* calcium nitrate is less attacked by denitrifying microbes than sodium or potassium nitrate, but in most soils calcium nitrate added will surely be changed by alkali-salts and nitrates of sodium or potassium be formed.

soil and the reduction can proceed so energetically in the sub-soil that all the nitrate applied may be reduced within a few weeks.

(5). Organic matters easily available to microbes favor denitrification to a large extent; further, straw or fresh rape cakes have more influence upon the reduction of nitrate than the same materials well rotten, which agrees with former observations on stable manure.

## PRACTICAL SUGGESTIONS.

(1). The Chili-saltpetre is no suitable fertilizer for plants grown in paddy soil.

(2). When Chili-saltpetre is to be used for paddy plants, organic manures should not be applied along with it, hence artificial mixed fertilizers composed of Chili-saltpetre and some organic substances are to be avoided for paddy fields.

(3) When however an organic fertilizer is unavoidably to be used along with Chili-saltpetre for paddy plants, the former should be used only in a well rotten state.

In conclusion, the authors express their hearty thanks for valuable suggestions and advice given by the Director Prof. Y. Kozai and Prof. Dr. O. Loew and for the analytical service given by Assistant Mr. C. Matsuoka.

A. Soil from Nishigahara.

(3) $NaNo_3$+glycerine. (2) $NaNO_3$. (1) $(NH_4)_2SO_4$.

B. Soil from Arakawa.

(3) $NaNO_3$+glycerine. (2) $NaNO_3$. (1) $(NH_4)_2SO_4$.

Vegetation Experiment II (a).

Vegetation Experiment II (b).

No. 1.=$(NH_4)_2SO_4$
No. 2.=$NaNO_3$.
No. 3.=$(NH_4)_2SO_4$+$NaNO_3$.
No. 4.=$NaNO_3$+Starch.
No. 5.=$NaNO_3$+Compost (a).
No. 6.=$NaNO_3$+Compost (b).
No. 7.=$NaNO_3$+Rape cake.
No. 8.=Rape cake only.
No. 9.=Compost (a) only.
No. 10.=Compost (b) only.
No. 11.=Starch only.
No. 12.=Control.

# Influence of Stimulating Compounds upon the Crops under Different Conditions.

BY

S. UCHIYAMA.

**Introductory Remarks.** A series of observations which have been carried on since 1902 at the College of Agriculture, Imperial Univ. Tokyo. have demonstrated that certain mineral salts applied in small doses cause stimulation of development. Special attention was paid to the action of manganese salt,[1] potassium iodide and sodium fluoride. Manganese occurs sometimes in considerable quantities in plant ashes and the presence of iodine, and fluorine in very small doses must be assumed in plants, to judge from their presence in animal organs. The degree of stimulation however varied considerably with different plant species and also with the manuring conditions. It was therefore necessary to extend the observations in this line in order to collect further information. I have carried out field experiments as well as pot experiments with varying manures and application of manganese with the general manure as well as in the form of top-dressing.

The soil serving for the field experiments was a diluvial loam rich in humus and containing 0.389 % N in the dry fine earth. The dry fine earth amounted to 97.70 % and showed the following composition :

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1). The stimulating effect of manganese salt has since been confirmed by Bertrand and several other authors. Bertrand calls such compound beneficial in small doses : supplementary manures.

| | Soluble in | | |
|---|---|---|---|
| | 10 % Hcl at 98°C. | 1% Hcl at room temperature after 7 days. | 1% citric acid after Dyer. |
| $Al_2O_3$ | 11.961 | 4.412 | 0.289 |
| $Fe_2O_3$ | 8.552 | 0.141 | 0.299 |
| $Mn_3O_4$ | 0.413 | 0.293 | 0.076 |
| CaO | 0.831 | 0.434 | 0.392 |
| MgO | 1.202 | 0.168 | 0.117 |
| $K_2O$ | 0.143 | 0.023 | 0.019 |
| $Na_2O$ | 0.097 | 0.017 | 0.014 |
| $P_2O_5$ | 0.276 | 0.011 | 0.033 |
| $SO_3$ | 0.191 | 0.012 | 0.019 |
| $SiO_2$ | 0.215 | 1.169 | 0.521 |

For the pot experiments, beside the above soil, also an alluvial sandy soil poor in organic matter was used, (0.135 % N in the dry fine earth) yielding 96.05 % dry fine earth of the following composition :

| | Soluble in | | |
|---|---|---|---|
| | 10 % Hcl at 98°C. | 1% Hcl at room temperature after 7 days. | 1% citric acid after Dyer. |
| $Al_2O_3$ | 3.787 | 0.351 | 0.095 |
| $Fe_2O_3$ | 4.830 | 1.189 | 0.518 |
| $Mn_3O_4$ | 0.290 | 0.134 | 0.054 |
| CaO | 0.718 | 0.398 | 0.247 |
| MgO | 1.177 | 0.313 | 0.116 |
| $K_2O$ | 0.158 | 0.021 | 0.012 |
| $Na_2O$ | 0.095 | 0.021 | 0.018 |
| $P_2O_5$ | 0.172 | 0.030 | 0.025 |
| $SO_3$ | 0.056 | 0.011 | 0.012 |
| $SiO_2$ | 0.387 | 0.438 | 0.302 |

## A. Stimulating Action of Manganese.

### A). Field Experiment.

#### 1). Experiment with Barley and Wheat.

Four plots (area $= \frac{1}{100}$ ha.), received the following manures, each :

| | Ratio per ha. (kilo.) | |
|---|---|---|
| | for Barley | for Wheat |
| Compost ... ... ... ... ... ... ... ... ... | 7308 | 3657 |
| Common superphosphate ... ... ... ... ... ... | 165 | 165 |
| Straw-ash ... ... ... ... ... ... ... ... ... | 219 | 219 |
| Mixed human excreta ... ... ... ... ... ... | 2789 | 2088 |

On Oct. 4, 1903, the seeds were sown at the rate of 50 kilo. barley and 42 kilo. wheat per ha. To each plot of barley and wheat manganous sulphate was applied as top-dressing in high dilution in four fractional doses (Oct. 26, Jan. 11, March 7, April 12) so that the total amount corresponded to 33.2 kilo. $Mn_3O_4$ per ha., while at the same time the other two plots received the same doses of water.

At the first application of the manganous sulphate, the plants were about 10 cm. high. During vegetation, the treated plants developed somewhat more luxuriantly. On June 8, the plants were cut. The weight in the air-dry state was, kilo. :

| | plots. | Grains. | Straw. | Total. | Comparative Yield Grains of check plot = 100. |
|---|---|---|---|---|---|
| Barley | A Check | 41.32 | 69.50 | 110.82 | 100 |
| | B $MnSO_4$ | 43.95 | 69.62 | 113.57 | 106 |
| Wheat | A Check | 28.36 | 45.45 | 73 81 | 100 |
| | B $MnSO_4$ | 30.99 | 47.34 | 78.33 | 109 |

This result shows that the dose of 33.2 kilo. $Mn_3O_4$ per ha. had but a very moderate effect on barley and wheat in this case.

2). Experiment with Grasses.

The grasses serving for this experiment were alsike clover (or Sweidish Clover, *Trifolium hybridum*), Creeping Soft-grass (*Holcus mollis*) and Meadow Soft-grass (*Holcus lanatus*). Six plots, each measuring 4.96 square meters received the following manures:

For Gramineæ=4.5 kilo. human urine+72g secondary sodium phosphate,
„ Leguminosæ=53g. potassium sulphate+94g „ „ „

Manganese sulphate was applied at the rate of 25 kilo. $Mn_3O_4$ per ha. in solution in three fractions, i.e. Oct. 29, Jan. 11 and Mar. 10. The treated plants seemed continuously somewhat superior to the check plants. The plants were cut in 2–3 fractions, i.e. June 9, July 16 and Aug. 19 with the following result, kilo.:

| | | | First Crop. | Second Crop. | Third Crop. | Total. |
|---|---|---|---|---|---|---|
| Fresh state | Alsike Clover | Check plant | 7.737 | 8.188 | —— | 15.925 |
| | | Treated „ | 9.578 | 9.728 | —— | 19.306 |
| | Creeping Soft-grass | Check „ | 11.268 | 4.582 | 1.315 | 17.165 |
| | | Treated „ | 12.921 | 4.733 | 2.141 | 19.795 |
| | Meadow Soft-grass | Check „ | 12.883 | 9.615 | 1.540 | 24.038 |
| | | Treated „ | 13.860 | 12.395 | 2.441 | 28.696 |
| Air-dry state | Alsike Clover | Check „ | 1.352 | 2.254 | —— | 3.606 |
| | | Treated „ | 1.728 | 2.592 | —— | 4.320 |
| | Creeping Soft-grass | Check „ | 2.704 | 1.164 | 0.376 | 4.244 |
| | | Treated „ | 3.230 | 1.239 | 0.639 | 5.108 |
| | Meadow Soft-grass | Check „ | 2.216 | 1.878 | 0.413 | 4.507 |
| | | Treated „ | 2.479 | 2.554 | 1 052 | 6.085 |

If now we assume the total yield of the check plants respectively to be = 100, we obtain the following ratio :

| | Alsike clover. | Creeping Soft-grass. | Meadow Soft-grass. |
|---|---|---|---|
| Check plants ... ... ... ... | 100 | 100 | 100 |
| Treated plants... ... ... ... | 120 | 120 | 135 |

The effect of manganese sulphate was here very favorable.

### 3). Experiment with Buckwheat.

Three plots, each having an area of 33.1 square meters were manured Aug. 27 at the rate of 9000 litres human excreta, 375.7 kilo. straw ash and 225.4 kilo. common superphosphate per ha. Manganous sulphate was applied at the rate of 20 kilo. per ha., as follows :

Plot I. received no $MnSO_4$,
Plot II. „ $MnSO_4$ together with the manure, i.e. Aug. 27.
Plot III. „ „ as top-dressing in two fractions, i.e Sept. 8 and 22.

On Aug. 29, the seeds were sown at the rate of 90 kilo. per ha. The plants in plot II developed more luxuriantly in the beginning, while those in plot III excelled the former later on. The crop was harvested Nov. 1 and weighed in the air-dry state with the following result, kilo. :

| | Grains. | Straw. | Total. | Comparative Yield | |
|---|---|---|---|---|---|
| | | | | grains. | Total. |
| I. Control ... ... ... ... ... | 2.021 | 1.397 | 3.418 | 100 | 100 |
| II. $MnSO_4$ together with manure | 2.216 | 1.529 | 3.745 | 110 | 110 |
| III. $MnSO_4$ as top-dressing... ... | 2.367 | 1.773 | 4.140 | 117 | 121 |

This result shows that the manganese sulphate exerted a considerable stimulating influence on buckwheat when applied in the form of top-dressing, while the simultaneous application with the manure was much less favorable.

## 4). Experiment with Egg plant.

Two plots, eaeh having an area of $\frac{1}{200}$ ha., were manured with 4.22 kilo. ammonium sulphate, 2.81 kilo. common superphosphate and 1.59 kilo. potassium sulphate. On May 6, sixty young plants were transplanted to each plot. To one plot, manganese chloride was applied at the rate of 10 kilo. $Mn_3O_4$ per ha. as top-dressing in three fractions, i.e. July 1, July 28 and Aug. 19. The fruits of the egg plants were harvested at several periods when they became properly ripe as usual, and weighed in the fresh state with the following result:

| Date of harvest. | Control-plot. | | $MnCl_4$-plot. | |
|---|---|---|---|---|
| | No. of fruit. | Weight of fruit(g). | No. of fruit. | Weight of fruit(g). |
| July 15 ... ... ... | 41 | 2873.7 | 33 | 2768.5 |
| „ 18 ... ... ... | 2 | 89.2 | 4 | 179.3 |
| „ 20 ... ... ... | 4 | 170.65 | 4 | 185.57 |
| „ 24 ... ... ... | 19 | 1144.1 | 16 | 991.5 |
| „ 27 ... ... ... | 13 | 756.23 | 19 | 1208.02 |
| „ 28 ... ... ... | 44 | 2499.5 | 44 | 2378.7 |
| Aug. 1 ... ... ... | 25 | 2016.96 | 31 | 2432.45 |
| „ 5 ... ... ... | 30 | 2490.18 | 43 | 3509.87 |
| „ 8 ... ... ... | 40 | 3662.25 | 35 | 3202.15 |
| „ 10 ... ... ... | 38 | 3123.89 | 19 | 1564.4 |
| „ 15 ... ... ... | 32 | 3747.71 | 55 | 6413.69 |
| „ 18 ... ... ... | 78 | 6967.0 | 82 | 7237.0 |
| „ 19 ... ... ... | 54 | 2582.0 | 117 | 5743.0 |
| „ 21 ... ... ... | 32 | 1084.0 | 21 | 628.0 |
| „ 24 ... ... ... | 24 | 942.1 | 30 | 1358.1 |
| „ 28 ... ... ... | 116 | 4327.0 | 67 | 2670.0 |
| „ 30 ... ... ... | 25 | 662.5 | 19 | 392.5 |
| „ 31 ... ... ... | 68 | 1709 0 | 74 | 1892.5 |
| Sept. 4 ... ... ... | 78 | 1983.0 | 69 | 2652.0 |
| „ 6 ... ... ... | 135 | 2943.0 | 123 | 2772.0 |

| Date of harvest. | Control-plot. | | $MnCl_4$-plot. | |
|---|---|---|---|---|
| | No. of fruit. | Weight of fruit(g). | No. of fruit. | Weight of fruit(g). |
| Sept. 8 ... ... ... | 117 | 2628.0 | 105 | 1747.5 |
| „ 11 ... ... ... | 102 | 1902.0 | 87 | 1830.0 |
| „ 13 ... ... ... | 36 | 630.0 | 57 | 990.0 |
| „ 15 ... ... ... | 345 | 7152.0 | 375 | 8220.0 |
| „ 21 ... ... ... | 120 | 1956.0 | 90 | 1788.0 |
| „ 25 ... ... ... | 90 | 1368.0 | 93 | 1908.0 |
| „ 29 ... ... ... | 105 | 1920 0 | 159 | 2850.0 |
| Oct. 3 ... ... ... | 132 | 1608.0 | 132 | 1434.0 |
| „ 7 ... ... ... | 435 | 2907.0 | 615 | 4056.0 |
| Sum ... ... | 2380 | 67844.97 | 2618 | 75002.75 |

The plants were then plucked out, and the stalks with the roots were weighed in the fresh state with the following result, kilo. :—

| | Stalks and roots. |
|---|---|
| Control plot ... ... ... ... ... ... ... ... ... ... ... ... ... | 35.44 |
| Treated „ ... ... ... ... ... ... ... ... ... ... ... ... ... | 41.57 |

The following table shows conveniently the total harvest, kilo. :

| | Fruit. | Stalks and roots. | Total. | Comparative Yield. Fruit. | Comparative Yield. Stalks & roots. |
|---|---|---|---|---|---|
| I. Control plot ... ... ... | 67.84 | 35.44 | 103.28 | 100 | 100 |
| II. Trade plot ... ... ... | 75.00 | 41.57 | 116.57 | 111 | 117 |

Manganese chlorid exerted therefore here a favorable effect.

## 5). Experiment with Tea-plants.

For this experiment, two small plots were selected from our tea-farms ; the plants on these plots were of about equal development. Each plot, having an area of 1/375 ha. was manured with

28.40 kilo. human excreta
3.98 „ rice-bran
2.97 „ fish manure (herring)
} in the preceding autumn,
1.50 „ herring in the early spring.

To one plot, manganous sulphate was applied at the rate of 37.5 kilo. $Mn_3O_4$ per ha. as top-dressing in three portions, i. e. Oct. 9, March 11 and April 12. In the beginning of May, the leaves of the manganese plants showed a darker green color. The leaves were picked out on May 17, and weighed in the fresh state with the following result, kilo. :

| | Yield of Leaves. | Comparative Yield. |
|---|---|---|
| I. Control... ... ... ... ... ... ... | 14.25 | 100 |
| II. $MnSO_4$... ... .... ... ... ... ... | 18.38 | 129 |

Manganous sulphate exerted here a great influence on the leaf formation of the tea-plants.

## 6). Second Experiment with Tea-plants.

In this experiment, manganese sulphate was tested with the development of young tea-plants for two successive years. For this purpose, nine plots (area$=\frac{1}{2500}$ ha.) were selected from our experimental field of a diluvial loam rich in humus. Three plots received only manures, and the other three received manures + manganese sulphate, while another set of three plots remained without any application of manures as follows :

A No manure.
B Manure.
C Manure and manganese sulphate.

In the beginning of March, 1904, four wide holes were prepared in each plot : and to each hole of the plots B and C, 2.7 kilo. putrid excreta were applied. Two weeks later, each hole received 20 seeds of tea plants previously steaped in water ; thus each plot had four bundles of tea-plants. In the following spring, the young plants were reduced to eight per bundle of about equal size.

Experiment in the First Year:

Each bundle of the plots B and C was manured with 2 litres putrid urine, April 15, 1905. Manganese sulphate was applied to each bundle of the plots C at the rate of 20.3 kilo. per ha. as top-dressing in five fractions, i.e. April 20, May 2, 13, 22, and June 5. The plants of the plots C looked continuously better than those of the other plots. The following table shows the height of plants Nov. 10, 1905:

Average of each twelve bundles.

| Plots. | Height of plants, cm. |
|---|---|
| A No manure ... ... ... ... ... ... ... ... ... ... | 32.4 |
| B Manure ... ... ... ... ... ... ... ... ... ... ... | 36.7 |
| C Manure + $MnSO_4$ ... ... ... ... ... ... ... ... ... | 38.5 |

The adjoining plate XX shows the development, Nov. 10. Two bundles of each plot were then plucked out Nov. 1, and weighed with the following result, g.:

Average of two bundles.

| | | Leaves. | Stems and branches. | Roots. | Total. |
|---|---|---|---|---|---|
| Fresh state | A No manure ... ... | 82.4 | 64.1 | 94.5 | 241.0 |
| | B Manure ... ... ... | 111.2 | 85.4 | 127.2 | 323.8 |
| | C Manure + $MnSO_4$ ... | 124.8 | 95.4 | 125.9 | 346.1 |
| Air-dry state | A No manure ... ... | 40.0 | 31.2 | 32.7 | 103.9 |
| | B Manure ... ... ... | 52.7 | 41.4 | 28.93 | 132.4 |
| | C Manure + $MnSO_4$ ... | 61.3 | 47.7 | 28.38 | 152.2 |

If we now assume the total yield of the plots B in the air-dry state to be=100, we obtain the following ratio:

| Plots. | | Total Comparative Yield. |
|---|---|---|
| A | No manure ... ... ... ... ... ... ... ... ... ... ... | 78 |
| B | Manure ... ... ... ... ... ... ... ... ... ... ... ... | 100 |
| C | Manure+$MnSO_4$ ... ... ... ... ... ... ... ... ... ... | 115 |

Thus, it can be recognized that manganese sulphate favored the development of young tea-plants.

## Experiment in Seeond Year:

In the following spring, the remaining bundles of the plots B and C were manured each with 75.59 g. ammonium sulphate, 25.64 g. secondary sodium phosphate and 21 g. potassium sulphate. To each bundle of the plots C, manganese sulphate was applied at the rate of 12.19 kilo. per ha. as top-dressing in three fractions, i.e. April 13, May 29, and July 12. The manganese plants showed continuously a better development. The following table shows the height of plants on Nov. 22, 1906:

Average of each ten bundles.

| Pots. | | Height of plants, cm. |
|---|---|---|
| A | No manure ... ... ... ... ... ... ... ... ... ... ... | 53.0 |
| B | Manure ... ... ... ... ... ... ... ... ... ... ... ... | 70.3 |
| C | Manure+$MnSO_4$ ... ... ... ... ... ... ... ... ... ... | 72.4 |

The adjoining plate XX shows the development, Nov. 22. Two bundles of each plot were then plucked out No. 22, with the following result, g.:

Average of two bundles.

| | Pots. | Leaves. | Stems and branches. | Roots. | Total. |
|---|---|---|---|---|---|
| Fresh state | A No manure ... ... | 191.0 | 236.5 | 250.5 | 487.0 |
| | B Manure ... ... ... | 325.0 | 480.5 | 419.0 | 1224.5 |
| | C Manure + $MnSO_4$ ... | 393.0 | 498.0 | 428.0 | 1319.0 |
| Air-dry state | A No manure ... ... | 80.0 | 117.0 | 95.5 | 292.5 |
| | B Manure ... ... ... | 135.0 | 222.0 | 177.0 | 534.0 |
| | C Manure + $MnSO_4$ ... | 179.5 | 239.5 | 211.5 | 630.5 |

The total comparative yield in the air-dry state is calculated as follows :

| Plots. | Total Comparative Yield. |
|---|---|
| A No manure ... ... ... ... ... ... ... ... ... ... | 55 |
| B Manure ... ... ... ... ... ... ... ... ... ... ... | 100 |
| C Manure + $MnSO_4$ ... ... ... ... ... ... ... ... ... | 118 |

Manganese sulphate had also here acted favorably on the development of young tea-plants.

### 7). Experiment with Radish.

Two plots, each having an area of 1/200 ha., were manured at the rate of

10500 kilo. compost,
450 „ common superphosphate,
750 „ straw ash and
7494 litres human excreta, per ha.

On Oct. 21, 1904, the seeds were sown, and the number of shoots was afterward reduced to 280 per plot. To one plot, manganous sulphate was applied at the rate of 20 kilo. per ha. as top-dressing in three portions, i.e.

Feb. 7, 18 and March 29, the first application being made when the young plants had reached about 10 cm. On April 18, some decisive difference could be clearly observed, the treated plants showing a more luxuriant and darker green appearance.

The plants were harvested May 2, and weighed in the fresh state with the following results, kilo.:

| | Roots. | Leaves. | Total. | Comparative Yield. Roots. | Leaves. |
|---|---|---|---|---|---|
| Check plants ... ... ... | 144.49 | 78.88 | 223.37 | 100 | 100 |
| Treated plants ... ... | 175.41 | 94.65 | 270.06 | 121 | 120 |

Manganous sulphate had acted very favorably.

### 8). Second Experiment with Radish.

Manganous sulphate was here tested in two different applications, i.e. mixed with manure, and as top-dressing. The manganous sulphate was applied in each case at the rate of 20 kilo. per ha. Three plots, each having an area of 1/278 ha., were manured with 93.75 kilo. Compost, 62.63 kilo. human excreta, 3 kilo. common superphosphate and 6.26 kilo. straw ash. To one plot, the whole dose of manganous sulphate was then applied in solution. On Oct. 21, 1904, the seeds were sown, and the young plants were afterward reduced to 300 per plot. Manganous sulphate was applied to the other one plot as top-dressing in three portious i.e. Dec. 12, Feb. 18 and March 7. At the flowering period, the plants supplied with top-dressing of manganous sulphate showed a more luxuriant growth.

The plants were harvested on June 28, and weighed in the air-dry state with the following result, kilo.:

| | Grains. | Hucks. | Stalks and Roots. | Total. | Comparative yield. Grains. | Total. |
|---|---|---|---|---|---|---|
| I. Control ... ... ... ... ... | 6.01 | 9.25 | 10.10 | 25.36 | 100 | 100 |
| II. $MnSO_4$ together with manure... | 6.22 | 10.01 | 9.91 | 26.14 | 104 | 103 |
| III. $MnSO_4$ as top-dressing ... ... | 6.47 | 11.52 | 10.08 | 28.07 | 108 | 111 |

Hence it can be seen also here that manganous sulphate acts more effectively when applied as top-dressing than when mixed with the main manures.

9). Experiment with Beans.

Three plots, each having an area of 1/278 ha., were manured with 93.75 kilo. Compost, 31.13 kilo. human excreta, 1.58 kilo. common superphosphate and 3.11 kilo. straw ash. Manganous sulphate was applied at the rate of 20 kilo. per ha. The second plot received the whole dose of manganous sulphate a few days after the application of the general manures, while for the third plot it was applied as top-dressing in three fractional doses. On Oct. 21, 1904, the seeds were sown, and the number of shoots was afterward reduced to 300 per plot.

The plants were harvested June 26, and weighed in the air-dry state with the following result, kilo. :

| | Grains. | Stalks and Hucks. | Total. | Comparative yield. Grains. | Comparative yield. Total. |
|---|---|---|---|---|---|
| I. Control ... ... ... ... ... | 11.88 | 28.55 | 40.43 | 100 | 100 |
| II. $MnSO_4$ together with manure ... | 14.98 | 33.10 | 48.08 | 126 | 119 |
| III. $MnSO_4$ as top-dressing ... ... | 17.11 | 36.77 | 53.88 | 144 | 133 |

Manganese sulphate acted here very favorably and better in the form of top-dressing.

10). Experiment with *Brassica Campestris, Cul. Var. Hakusai.*

Three plots, each having an area of 1/400 ha., were manured with 26.25 kilo. compost, 16.20 kilo. human excreta, 1.88 kilo. straw ash, and 1.13 kilo. common superphosphate. Manganous sulphate was applied at the rate of 20 kilo. per ha. One plot received the whole dose of manganous sulphate a few days after the application of the general manures. To the other plot, manganous sulphate was applied as top-dressing in two fractions, i.e. Sept. 28, and Oct. 8. On Sept. 8, 1904, the seeds were sown, and the young shoots afterwards reduced to 240 per plot. The plants were harvested Nov. 24, and weighed in the fresh state with the following result, kilo. :

| | Total yield. | Comparative yield. |
|---|---|---|
| I. Control... ... ... ... ... ... ... ... | 136.42 | 100 |
| II. $MnSO_4$ together with manure ... ... ... | 147.38 | 108 |
| III. $MnSO_4$ as top-dressing ... ... ... ... | 154.80 | 114 |

Manganese sulphate had favored the development of *Brassica campestris*, especially in the form of top-dressing.

11). Experiment with *Brassica Campestris, cul. var. Mikawashima-na.*

Three plots, each having an area of 1/278 ha., manured with 93.75 kilo. compost, 62.63 kilo. human excreta, 3 kilo. common superphosphate and 6.26 kilo. straw ash. Manganous sulphate was applied at the rate of 20 kilo. per ha. One plot received the whole dose of manganous sulphate a few days after the application of the general manures, while the third plot received it as top dressing, Dec. 12, Feb. 18 and March 7. On Oct. 21, 1904, the seeds were sown, and the number of shoots afterwards reduced to 375 per plot.

The plants were harvested on March 27, and weighed in the fresh state with the following result, kilo.:

| | Total yield. | Comparative yield. |
|---|---|---|
| I. Control ... ... ... ... ... ... ... | 82.31 | 100 |
| II. $MnSO_4$ together with manure ... ... | 90.38 | 110 |
| III. $MnSO_4$ as top-dressing ... ... ... ... | 101.06 | 123 |

This result is quite in accordance with that of the preceding experiment.

12). Third Experiment with Radish.

An experiment made by Prof. Loew[1] with tobacco had shown that the simultaneous application of manganese and iron salts exerted a better effect on the development than when each of these salts was applied alone. Under certain circumstances, it may occur however that the simultaneous application of both those salts is not so advantageous as when each is

1). Bulletin of the College of Agr. Tokyo Imperial University, Vol. VI., No. 2, P. 168.

applied alone. On soils rich in manganese and poor in iron, the result will differ from that on soils poor in manganese and rich in iron. In order to collect further material, therefore, we have observed the effects of top-dressing with both sulphates upon radish.

Plot I. Control,
„ II. Ferrous sulphate alone, 20 kilo. per ha.
„ III. Ferrous sulphate + manganous sulphate, 20 kilo. each per ha.
„ IV. Manganous sulphate alone, 20 kilo. per ha.

To each plot measuring 17.5 square meter, the following manures were applied:

| | | |
|---|---|---|
| Compost | 10500 kilo. | per ha. |
| Common superphosphate | 450 „ | |
| Straw ash | 750 „ | |
| Human excreta | 6494 litres | |

On August 8, 1904, the seeds were sown, and the number of shoots afterwards reduced to 60 per plot. After the young plants had reached about 10 cm., they received the top-dressing of manganous and ferrous sulphate at the following dates:

On Aug. 26, 7.056 g. salt in 0.1303 ‰ solution,
„ Sept. 5. 10.583 g. „ „ 0.1955 ‰ „
„ „ 22, 17.939 g. „ „ 0.3259 ‰ „

On Sept. 5, some decisive difference could be clearly noticed, the treated plants showing a more luxuriant and darker green appearance.

The plants were harvested on Oct. 7, and the roots as well as the leaves were weighed in the fresh state with the following results, kilo.:

| | Roots. | Leaves. | Total | Comparative yield. Roots. | Leaves. |
|---|---|---|---|---|---|
| I. Control | 23.850 | 20.925 | 44.775 | 100 | 100 |
| II. $FeSO_4$ | 30.000 | 23.963 | 53.963 | 126 | 115 |
| III. $FeSO_4 + MnSO_4$ | 30.825 | 25.313 | 56.138 | 129 | 121 |
| IV. $MnSO_4$ | 32.100 | 25.950 | 58.050 | 135 | 124 |

The adjoining plate XXI exhibits the differences very clearly. Stimulation was therefore caused on the three plots and the result of joint

application of both sulphates remained between that obtained with ferrous sulphate and manganous sulphate alone.

13). Experiment with up-land rice.

Manganous sulphate was here applied in conjunction with ferrous sulphate. Two plots, each measuring 1/300 ha. were manured[1] at the rate of 6385 kilo., compost, 4327 kilo. mixed excrement, 225.4 kilo. soy-bean cake, 112.7 kilo. straw ash and 225.4 kilo. common superphosphate per ha. The seeds (100 g.) of upland rice were then sown May 10, 1904. To one plot, solutions of manganous sulphate and ferrous sulphate were applied as top-dressing in three fractions so that the total doses of each salt amounted to 15 kilo., each per ha.; while at each respective period, water, corresponding to the volume of these solutions was added to the check plot. The first dose of manganous sulphate was applied when the plants were about 10 cm. high. The following table shows the date regarding the application of both these sulphates:

| | | First dose. | Second dose. | Third dose. |
|---|---|---|---|---|
| Manganous sulphate... | Kilo. per ha.... ... | 2 | 5 | 8 |
| | Date ... ... ... | June 2 | June 18 | July 20 |
| Ferrous sulphate ... ... | Kilo. per ha.... ... | 2 | 5 | 8 |
| | Date ... ... ... | June 9 | June 26 | July 20 |

During vegetation, the plants treated with both sulphates showed a somewhat better development.

The plants were cut Sept. 10, and weighed in the air-dry state with the following result, kilo.:

| | Grains. | Straw. | Chaffs. | Total. | Comparative yield of grains. |
|---|---|---|---|---|---|
| Check plants ... ... | 10.86 | 14.96 | 0.60 | 26.42 | 100 |
| Treated plants ... ... | 11.46 | 16.16 | 0.65 | 28.27 | 106 |

1). The manuring principals were 76 kilo. nitrogen, 61 kilo. phosphoric acid and 55 kilo. potassa per ha.

This result shows that small doses of manganese and iron applied had but very little, if any stimulating effect. The doses must, for rice at least be increased, an observation made also by Nagaoka with paddy rice.

### 14). Experiment with Carrots.

Four plots, each having an area of 1/400 ha. received 26.25 kilo. compost, 1.88 kilo. straw ash, 1.14 kilo. soybean cake, and 1.13 kilo. common superphosphate. Manganous and ferrous sulphate were applied at the rate of 20 kilo. each per ha. as top-dressing in three fractions. On July 15, 1904, the seeds were sown, and the number of shoots afterwards reduced to 300 per plot. When the young plants had reached about 10 cm. in hight, they received a top-dressing of manganous and ferrous sulphate, i.e. Aug. 18, Sept. 5 and Sept. 22.

The plants were harvested on Nov. 25, and weighed in the fresh state with the following result, kilo.:

| | | | | Comparative yield. | |
|---|---|---|---|---|---|
| | Roots. | Leaves. | Total. | Roots. | Leaves. |
| I. Control... ... ... ... | 37.83 | 18.75 | 56.58 | 100 | 100 |
| II. $FeSO_4$... ... ... ... | 38.62 | 19.33 | 57.95 | 102 | 103 |
| III. $FeSO_4 + MnSO_4$ ... | 45.32 | 20.33 | 65.65 | 120 | 108 |
| IV. $MnSO_4$ ... ... ... | 45.53 | 21.54 | 67.07 | 120 | 115 |

From the above result, it can be seen that the application of manganous sulphate alone caused an increase of 20% roots, while manganous and ferrous sulphate in joint application led to the same result.

### 15). Second Experiment with *Brassica Campestris, Cul. var. Hakusai.*

Four pots, each having an area of 1/750 ha., were manured with 13.99 kilo. compost, 8.64 kilo. human excreta, 1.09 kilo. straw ash and 0.6 kilo. common superphosphate. On Sept. 8, 1904, the seeds were sown, and the number of shoots was afterward reduced to 180 per plot.

Manganous and ferrous sulphate were applied at the rate of 20 kilo. each per ha. as top-dressing in two fractions, i.e. Sept. 28 and Oct. 8.

During vegetation, the treated plants showed a more luxuriant and darker green appearance. The plants were harvested Nov. 24, and weighed in the fresh state with the following result, kilo.:

| | Total yield. | Comparative yield. |
|---|---|---|
| I. Control ... ... ... ... ... ... ... | 57.26 | 100 |
| II. $FeSO_4$ ... ... ... ... ... ... ... | 66.09 | 115 |
| III. $FeSO_4 + MnSO_4$ ... ... ... ... ... | 67.59 | 118 |
| IV. $MnSO_4$ ... ... ... ... ... ... ... | 71.16 | 127 |

Thus the application of manganous sulphate alone caused an increase of 27%, while manganous and ferrous sulphate in joint application 18% and ferrous sulphate alone 15%.

## 16). Experiment with Sweet-potatoes.

Two plots, each measuring 1/100 ha. were manured at the rate of 3756 kilo. compost, 563 kilo. straw ash and 113 kilo. common superphosphate per ha. On May 22, 1904, 330 young shoots were transplanted to each plot. Solutions of manganous sulphate and ferrous sulphate were applied to one plot as top-dressing in three fractions, i.e. July 19, Aug. 2 and Aug. 16 so that the total dose of each salt amounted to each 15 kilo. per ha., while the check plot received only water.

Leaves of the plants treated with sulphates of manganese and iron showed also here a darker green color than those of the check plants. The plants were harvested Nov. 10 and weighed in the fresh state with the following result, kilo.:

| | Tubers. | Runners, leaves, etc. | Total. | Comparative yield of tubers. |
|---|---|---|---|---|
| Check plants ... ... ... | 125.98 | 227.07 | 353.05 | 100 |
| Treated plants ... ... ... | 170.35 | 247.65 | 418.00 | 135 |

This result shows that the joint application of sulphates of manganese and iron increased the harvest by 35% in tubers.

17). Second Experiment with Sweet-potatoes.

Manganous sulphate was here applied separately with ferrous sulphate each at the rate of 15 kilo. per ha. Three plots, each having an area of 1/100 ha. were manured with 2.69 kilo. sodium nitrate, 25 kilo. straw ash and 1.29 kilo. secondary sodium phosphate. On May 28, 330 young shoots of potato-plants were transplanted to each plot. The first plot served as a Check, the second received a top-dressing of ferrous sulphate, and the third received manganous sulphate. The sulphates of manganese and iron were applied in solution in three fractions, i.e. July 15, 28 and Aug. 12.

The plants of the plots II and III showed a darker green color and better growth than those of the control plot. The plants were harvested Oct. 25, and weighed in the fresh state with the following result, kilo. :

| | Tubers. | Runners. | Total. | Comparative yield of tubers. |
|---|---|---|---|---|
| I. Control... ... ... ... | 107.85 | 245.10 | 352.95 | 100 |
| II. $FeSO_4$ ... ... ... ... | 131.06 | 255.11 | 386.17 | 121 |
| III. $MnSO_4$ ... ... ... | 144.68 | 263.63 | 408.31 | 134 |

This result agree with that of the preceding experiment, showing that sulphate of manganese as well as iron acts very favorably on the yield of sweet potatoes and that manganese was superior to iron.

## B). Pot Experiments.

### 1). Experiment with *Polygonum Tinctrium*.

This experiment was carried out in tall zinc bottomless cylinders inserted in the ground. Eight cylinders (area = 1/18180 ha.) were filled each with 256.8 kilo. air-dry soil, a diluvial loam. Four of them served as check, while the other four received manganese sulphate at the rate of 15 kilo. per ha. On April 15, each cylinder was manured with 60 g. ammonium sulphate, 32 g. secondary sodium phosphate and 26 g. potassium sulphate. Four days later, the seeds of *Polygonum tinctrium* were sown, and the young shoots afterwards reduced 56 per cylinder of about equal

size in seven bundles, each consisting of eight individuals. Dilute solution of manganese sulphate was applied as top-dressing in three portions, i.e. June 6, 16, and 27. During vegetation, the manganese plants looked continuously better than the control plants. The plants were cut in two periods, i.e. the first crop on June 17 and the second on July 4. The following table shows the harvest, g. :—

Average of four Parallel Cylinders.

| | | | Leaves. | Stalks. | Total. |
|---|---|---|---|---|---|
| Fresh state | Control plants | First crop ... ... | 999.2 | 674.7 | 1673.9 |
| | | Second crop ... | 598.3 | 539.0 | 1137.3 |
| | | Sum ... ... ... | **1597.5** | **1213.7** | **2811.2** |
| | Mn-plants | First crop ... ... | 1081.3 | 774.5 | 1855.8 |
| | | Second crop ... | 677.3 | 626.7 | 1304.0 |
| | | Sum ... ... ... | **1758.6** | **1401.2** | **3159.8** |
| Air-dry state | Control plants | First crop ... ... | 137.0 | 58.5 | 195.5 |
| | | Second crop ... | 84.8 | 71.0 | 155.8 |
| | | Sum ... ... ... | **221.8** | **129.5** | **351.3** |
| | Mn-plants | First crop ... ... | 153.2 | 61.9 | 215.1 |
| | | Second crop ... | 96.7 | 78.5 | 175.2 |
| | | Sum ... ... ... | **249.9** | **140.4** | **390.3** |

| | Control plants. | Manganese-p'ants. |
|---|---|---|
| Ratio of total harvest in leaves (air-dry state) | 100 | 113 |

Manganese had therefore moderately stimulated the development of *Polygonum tinctrium*.

2). Experiment with Buckwheat.

Eight zinc bottomless cylinders (area=1/18180 ha.) inserted in the field were filled each with 256.8 kilo. air-dry soil, a diluvial loam rich in humus. Four of them served as a check, while the other four received manganese sulphate at the rate of 20 kilo. per ha. On June 27, each cylinder was manured with 25 g. ammonium sulphate and 30 g. common superphosphate, and a week later again with 10 g. potassium carbonate. On July 5, eighty-six seeds of buckwheat were sown per cylinder. Manganese sulphate was applied as top-dressing in two fractions, i.e. July 18 and 26. The plants were harvested Sept. 3 with the following result, g.:

Average of four parallel cylinders in the air-dry state.

| | Grains. | Straw. | Total. | Comparative yield of Grains. |
|---|---|---|---|---|
| Control plants ... ... ... | 112.20 | 147.32 | 259.52 | 100 |
| Mn-plants ... ... ... ... | 122.11 | 152.02 | 274.13 | 109 |

Thus the plus-yield of the grains of buckwheat caused by the manganese amounted to 9%.

3). Experiment with Radish.

Eight zinc bottomless cylinders (area=1/18180 ha.) inserted in the ground were filled each with 256.8 kilo. air-dry soil, a diluvial loam rich in humus. Four of them served as a check, while the other four received manganese sulphate at the rate of 30 kilo. per ha. On Aug. 4, each cylinder was manured with 18 5 g. potassium carbonate, and five days later again with 60 g. ammonium sulphate and 48.1 g. common superphosphate. On Aug. 10, fourty five radish seeds were sown per cylinder, and the young shoots were later reduced to three per cylinder of about equal size. Manganese sulphate was applied as top dressing in three fractions, i.e. Sept. 4, 18 and Oct. 1. The plants were harvested on Oct. 20, and weighed in the fresh state with the following result, kilo.:

Average of four parallel cylinders.

| | Roots. | Leaves. | Total. | Comparative yield of roots. |
|---|---|---|---|---|
| Control plants ... ... ... | 3.563 | 1.613 | 5.176 | 100 |
| Mn-plants ... ... ... ... | 4.088 | 1.838 | 5.926 | 115 |

Thus the plus-yield of roots produced by manganese salt was here 15 %.

4). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of 1/95500 ha. was filled with 26.67 kilo. dry soil, a diluvial loam. Manganese sulphate was applied at the rate of

| | | |
|---|---|---|
| I. | 0 | |
| II. | 10 kilo. | |
| III. | 25 ,, | $Mn_3O_4$ per ha. |
| IV. | 50 ,, | |
| V. | 100 ,, | |
| VI. | 500 ,, | |

For each series, fifteen cylinders were prepared. On Nov. 2, each cylinder received 17.48 g. ammonium sulphate and 8.43 g. common superphosphate and 21.5 g. kainit; and again received 30 seeds of six-sided barley. The young shoots were afterwards reduced to 20 per cylinder of about equal size. Dilute solution of manganese sulphate was applied as top-dressing in three fractions, i.e: March 19, April 17 and May 1.

During vegetation, the plants supplied with the medium dose of manganese sulphate III looked most vigorous. The following table shows the data regarding the growth at May 24:

Average of fifteen parallel cylinders.

| Cylinders. | $Mn_3O_4$ per ha. | Height cm. | No. of stalk. |
|---|---|---|---|
| I. | 0 | 92.7 | 40 |
| II. | 10 kilo. | 95.7 | 41 |

| Cylinder. | $Mn_3O_4$ per ha. | Height cm. | No. of stalk. |
|---|---|---|---|
| III. | 25 Kilo. | 93.0 | 49 |
| IV. | 50 „ | 93.8 | 48 |
| V. | 100 „ | 91.7 | 46 |
| VI. | 500 „ | 89.6 | 43 |

The plants were harvested on June 8, and weighed in the air-dry state with the following result, g. :

Average of fifteen parallel cylinders.

| Cylinders. | $Mn_3O_4$ per ha. | Grain. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I. | 0 | 65.8 | 84.0 | 5.2 | 155.0 | 100 | 100 |
| II. | 10 kilo. | 74.8 | 95.3 | 6.8 | 176.9 | 114 | 114 |
| III. | 25 „ | 77.8 | 107.2 | 7.7 | 192.7 | 118 | 124 |
| IV. | 50 „ | 73.4 | 101.6 | 6.8 | 181.8 | 112 | 117 |
| V. | 100 „ | 72.1 | 97.2 | 7.0 | 176.3 | 110 | 114 |
| VI. | 500 „ | 67.0 | 91.4 | 6.8 | 165.2 | 102 | 107 |

This result shows that manganese sulphate acts favorably on the yield of barley, the optimum amount being 25 kilo. $Mn_3O_4$ per ha., which agrees exactly with the most favorable dose observed by Nagaoka for paddy rice.

### 5) Experiment with *Panicum Miliaceum.*

This experiment was carried out with tall zinc cylinders (bottomless) inserted in the ground. Fourteen cylinders, each having an area of 1/20000 ha., were filled with 18.75 kilo. air-dry soil (an alluvial sand).

The sulphate of manganese and iron were jointly applied as follows :

| | Each sulphate applied. | |
|---|---|---|
| | Per pot (g.) | Per ha. (kilo.) |
| I. | 0 | 0 |
| II. | 0.047 | 9.4 |
| III. | 0.094 | 18.8 |

| | Each sulphate applied. | |
|---|---|---|
| | Per pot (g.) | Per ha. (kilo.) |
| IV. | 0.141 | 28.2 |
| V. | 0.188 | 37.6 |
| VI. | 0.376 | 75.2 |
| VII. | 0.940 | 188.0 |

Each cylinder was manured on June 20 with ammonium sulphate, secondary sodium phosphate and potassium sulphate at the rate of 56.3 kilo. phosphoric acid, and 75 kilo. each of nitrogen and potassa per ha. Three days later, the seeds were sown, and the young shoots reduced to four per cylinder of about equal size. The sulphate of manganese and iron were applied as top-dressing in three fractions, i.e. July. 13, 26 and Aug. 3. The plants supplied with the sulphate of manganese and iron developed gradually better than those of the control cylinders. The plants were harvested on Sept. 5, and weighed in the air-dry state with the following result, g. :

Average of two parallel pots.

| Cylinders. | Sulphate of manganese and iron per ha. | Grains. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I. | 0 | 22.9 | 30.7 | 3.2 | 56.8 | 100 | 100 |
| II. | 9.4 kilo. | 24.9 | 33.8 | 3.1 | 61.8 | 109 | 109 |
| III. | 18.8 „ | 25.8 | 34.2 | 4.0 | 64.0 | 112 | 113 |
| IV. | 28.2 „ | 27.3 | 36.5 | 5.2 | 69.0 | 119 | 121 |
| V. | 37.6 „ | 26.8 | 35.2 | 4.3 | 66.3 | 117 | 117 |
| VI. | 75.2 „ | 25.5 | 34.0 | 3.8 | 63.3 | 111 | 111 |
| VII. | 18.8 „ | 23.4 | 33.5 | 3.5 | 60.4 | 102 | 106 |

The joint application of manganese and iron salt acted therefore most favorably with the dose of 28.2 kilo. per ha. of each sulphate.

### 6). Experiment with Hemp.

In this experiment, two different kinds of soils i.e. an alluvial sand and a diluvial loam were applied. Four zinc pots, each having an area of 1/13750 ha., were filled with 30 kilo. sandy soil and the other four received 22.5 kilo. loamy soil. Each pot again received 3 g. double superphosphate, 30 g. kainit and 5 g. ammonium nitrate on April 29. Further, 7.5 g. ammonium nitrate was applied as top-dressing in three fractions, i.e. May 27, July 12 and 27. Manganese sulphate was applied at the rate of 66.6 kilo. salt per ha. as top-dressing in two fractions i e. May 5 and 27.

On April 29, one hundred seeds of hemp were sown in each pot, and the young shoots, later reduced to 45 per pot.

During vegetation, the manganese-plants looked somewhat darker green and more luxuriant. The plants were harvested on July 17, and weighed in the fresh state with the following result, g.:

Average of two parallel pots.

| Soil. | Pot. | Stalks. | Roots. | Leaves. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Stalks. | Total. |
| Sandy soil | Control ... ... | 336.7 | 56.9 | 219.0 | 612.6 | 100 | 100 |
| | $MnSO_4$... ... | 380.1 | 59.2 | 234.8 | 674.1 | 113 | 110 |
| Loamy soil | Control ... ... | 258.3 | 39.7 | 149.3 | 447.3 | 100 | 100 |
| | $MnSO_4$... ... | 297.4 | 43.1 | 164.3 | 504.8 | 115 | 113 |

This result shows that hemp is moderately stimulated by manganese sulphate on sandy as well as on loamy soil.

### 7). Experiment with Beans.

On October 25, twelve zinc pots, each having an area of 1/200000 ha. received 10 kilo. air-dry soil, an alluvial sand, and four days later they were manured with 1.19 g. ammonium sulphate, 3.64 g. common superphosphate

and 10.24 g. kainit. They received again manganese sulphate at the rates of 20 and 200 kilo. salt per ha. in two different application, i.e. together with the manure and as top-dressing in five fractions (March 9, 22, April 6, 14 and 21) as follows :

Pots I with manure only
„ II 0.1 g. manganese sulphate } together with manure,
„ III 1.0 g. „ „ }
„ IV 0.1 g. „ „ } in five fractions.
„ V 1.0 g. „ „ }

The pots were prepared in duplicate, while for the series I four parallel pots were prepared. On Oct. 31, two seeds of beans previously steaped in water were sown per pot.

In the beginning, the plants of the pots II and III looked more vigorous than those of the others, while towards the end of vegetation those of the pots III and IV seemed most luxuriant. The plants were harvested on June 27. The average weight in the air-dry state was as follows, g. :

| Pots. | $MnSO_4$ | Grains. | Straw and Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|
| | | | | | Grains. | Total. |
| I | Control ... ... ... ... ... ... | 19.3 | 22.4 | 41.7 | 100 | 100 |
| II | 0.1 g. $MnSO_4$ together with manure | 29.2 | 25.8 | 55.0 | 151 | 132 |
| III | 1.0 g. „ „ „ „ | 31.9 | 25.9 | 57.8 | 165 | 138 |
| IV | 0.1 g. „ in five fractions ... | 30.4 | 30.3 | 60.7 | 158 | 146 |
| V | 1.0 g. „ „ „ „ ... | 26.6 | 24.6 | 51.2 | 128 | 123 |

This result shows that :

1). Manganese sulphate favors considerably the growth of beans, especially increasing the yield of grains.

2). Top-dressing at the *small* rate of 20 kilo. per ha. was more powerful than the application with the general manure (compare IV with II).

3). Top-dressing at the very *high* rate had less effect than the same dose with the general manure. Also here the more powerful effect of an excessive dose is noticed in the form of top-dressing.

8). Experiment with Sesamum under Acidic and Alkaline Manure.

On June 26, each zinc pot having an area of 1/137500 ha. received 15 kilo. air-dry soil from unmanured plot of our experimental field (a diluvial loam). Pot $A_1$–$A_5$ were manured with alkaline manure, i.e. 150 c.c. rotten urine and 15 g. bone dust. They received the following amounts of manganese sulphate :

Pot $A_1$ With alkaline manure only.
„ $A_2$ 0.3 g. Manganese sulphate corresponding to 41.25 kilo. salt per ha.
„ $A_3$ 0.75 g. „ „ „ „ 103.125 „ „ „ „
„ $A_4$ 1.5 g. „ „ „ „ 206.25 „ „ „ „
„ $A_5$ 3.0 g. „ „ „ „ 412.50 „ „ „ „

At the same time, pot $B_1$-$B_4$ received 7.5 g. double superphosphate, 15 g. each of kainit and sodium nitrate, and the following doses of manganese sulphate :

Pot $B_1$ With acidic manure only.
„ $B_2$ 0.3 g. salt dissolved in 1 litre and applied together with manure,
„ $B_3$ 0.3 g. „ in two fractions, i.e. July 20 and 28,
„ $B_4$ 0.6 g. „ in four „ i.e. July 20, 28, Aug. 5 and 19.

On June 28, twenty seeds were sown per pot, and the young shoots reduced to 5 per pot of about equal size. On Aug. 5 between the pots $A_1$–$A_5$ no decisive difference could be observed, while in the case of pots $B_1$–$B_4$ the manganese plants seemed more luxuriant.

The plants were harvested on Sept. 22, and weighed in the air-dry state with the following result, g. :

I). Alkaline Manure :

| Pots. | $MnSO_4$ | Full grains. | Empty grains. | Stalks and husks. | Total. | Comparative yield of full grains. |
|---|---|---|---|---|---|---|
| $A_1$ | Control ... ... ... ... | 15.35 | 0.50 | 37.75 | 53.60 | 100 |
| $A_2$ | 0.3 g. $MnSO_4$ ... ... ... | 15.00 | 0.60 | 37.90 | 53.50 | 98 |
| $A_3$ | 0.75 g. „ ... ... ... | 15.00 | 0.30 | 36.50 | 51.80 | 98 |
| $A_4$ | 1.5 g. „ ... ... ... | 15.80 | 0.40 | 39.60 | 55.80 | 103 |
| $A_5$ | 3.0 g. „ ... ... ... | 15.35 | 0.35 | 36.05 | 51.75 | 100 |

II). Acidic Manure :

| Pots. | $MnSO_4$ | Full grains. | Empty grains. | Stalks and husks. | Total. | Comparative yield of full grains. |
|---|---|---|---|---|---|---|
| $B_1$ | Control ... ... ... ... | 20.30 | 0.30 | 48.20 | 68.80 | 100 |
| $B_2$ | 0.3 g. salt with manure... | 22.25 | 0.50 | 54.65 | 77.40 | 110 |
| $B_3$ | 0.3 g. „ in 2 fractions... | 22.30 | 0.50 | 50.50 | 71.30 | 110 |
| $B_4$ | 0.6 g. „ „ 4 „ ... | 22.60 | 0.30 | 51.90 | 74.80 | 111 |

From this result, we learn that,

1). The stimulating action of manganese is greatly influenced by the reaction of the manure applied. Acidic manure seems to be favorable to the action of manganese, while alkaline manure interferes with the effect of manganese, which may perhaps be due to the precipitation of manganese by the alkaline manure.

2). Under favorable manuring conditions manganese can be safely applied together with the manure (compare $B_2$ with $B_3$ and $B_4$), although as top-dressing it will be preferable in many cases.

9). Experiment with Spinach under Acidic and Alkaline Manure.

Eighteen zinc pots, each having an area of 1/200000 ha., were filled with 16 kilo. air-dry soil from an unmanured plot of our experimental field (a diluvial loam). To five pots, alkaline manure was applied, and to the other four acidic manure as foliows :

I. Alkaline manure (10 pots) { 100 c.c. rotten urine, 10 g. steamed bone dust.

II. Acidic manure ... (8 pots) { 5 g. double superphosphate, 10 g. kainit, 10 g. sodium nitrate.

The manure was carefully mixed with the soil on July 23, and only the putrid urine was simultaneously applied with manganous sulphate on Aug. 13. The relations were as follows :

Manganese sulphate per pot.

I. Alkaline manure
- 0
- 0.2 g. together with the manure,
- 0.5 g. „ „ „ „
- 1.0 g. „ „ „ „
- 2.0 g. „ „ „ „

II. Acidic manure
- 0
- 0.2 g. as top-dressing in 2 fractions,
- 0.3 g. „ „ „ 3 „
- 0.2 g. together with the manure.

On Aug. 15, twenty seeds were sown per pot, and the young shoots reduced to six per pot of about equal size. Manganous sulphate in fractional doses were applied I Sept. 15, II Oct. 7, and III Oct. 15. On Oct. 7, some difference in growth could be noticed, the manganese plants showing more luxuriance.

The plants were harvested Oct. 28, and weighed in the fresh state with the following result, g.:

I). Alkaline manure:

| Pots. | Manganous sulphate. | | | Yield per pot. | Comparative yield. |
|---|---|---|---|---|---|
| | Per pot g. | Per ha. kilo. | Mode of application. | | |
| I | 0 | 0 | 0 | 23.3 | 100 |
| II | 0.2 | 40 | together with the manure | 23.7 | 102 |
| III | 0.5 | 100 | „ „ „ „ | 29.4 | 126 |
| IV | 1.0 | 200 | „ „ „ „ | 30 9 | 133 |
| V | 2.0 | 400 | „ „ „ „ | 27.1 | 116 |

It will be noticed that the maximum yield was obtained by the application of manganese sulphate in the rate of 200 kilo. per ha. in presence of a manure of alkaline nature. The ratio of 400 kilo. per ha. led already to some depression.

II). Acidic manure:

| Pots. | Manganous sulphate. | | | Yield per pot. | Comparative yield. |
|---|---|---|---|---|---|
| | Per pot g. | Per ha. kilo. | Mode of application. | | |
| I | 0 | 0 | 0 | 57.1 | 100 |
| II | 0.2 | 40 | As top-dressing in a fractions | 73.8 | 129 |
| III | 0.3 | 60 | „ „ „ „ 3 „ | 74.3 | 130 |
| IV | 0.2 | 40 | together with the manure | 60.3 | 106 |

This result shows that fractional top-dressing led to a better yield than the simultaneous application of manganese with the manure. It will be also seen that the ratio of 40 kilo. manganese sulphate per ha. had a greater relative effect with the acidic than with the alkaline manure. It appears then, that alkaline manure renders the manganese sooner un-available than the acidic manure which may be easily understood, since the manganese sulphate is transformed sooner into insoluble manganese compounds.

10). Experiment with Paddy-rice.

Two different soils, a diluvial loamy soil rich in humus and an alluvial sandy soil poor in humus served for this test. Thirty two zinc pots (area=1/200,000 ha.) were filled each with 17.63 kilo. loamy soil, while another set of thirty two pots received 21.38 kilo. of the sandy soil. Manganese sulphate was here tested at the rate of 30 kilo. per ha. with four manurial mixtures, hence sixteen groups of pots were prepared, each consisting of four pots. The manurial mixtures were as follows :

| Manures | A | B | C | D |
|---|---|---|---|---|
| Ammonium sulphate ... ... ... | 12 g. | ditto. | ditto. | ditto. |
| Double superphosphate ... ... ... | 5 g. | ditto. | — | — |
| Di-sodium phosphate ... ... ... | — | — | 10.2 g. | ditto. |
| Potassium sulphate ... ... ... ... | 10 g. | — | 10 g. | — |
| Potassium carbonate ... ... ... ... | — | 7.93 g. | — | 7.93 g. |
| Sodium sulphate... ... ... ... ... | 9.2 g. | ditto. | — | — |
| Limestone ... ... ... ... ... ... | — | — | 1.25 g. | ditto. |

In each of the above four mixtures, the amounts of phosphoric acid and of potassa respectively were equal, i.e. 2.02g. $P_2O_5$ and 5.41 g. $K_2O$. Since the superphosphate in the pots A and B provides the soil with a small dose of lime i.e. 0.7 g. CaO, the corresponding amount of lime was added to the pots C and D in the form of pulverized limestone $<$0.5 m.m. Since, on the other hand, the sodium phosphate in the pots C and D provides the soil with 1.77 g. $Na_2O$, the corresponding amount of soda was added to the pots A and B in the form of sodium sulphate. Of these four mixtures, A was decidedly acidic, D decidedly alkaline, while B and C were probably neutral or nearly so.

All the manurial compounds were applied June 10, 1906, with the exception of potassium carbonate which was applied a week later, while manganese sulphate was applied still five days later.

On June 22, each pot received eight individuals of young paddy rice plants of about equal size (20 cm.) in a bundle.

During vegetation, the plants of the pots with manganese sulphate looked more vigorous than those of the check pots, although the development of the plants differed greatly on the other hand from the nature of manures applied. The following table shows the height of plants and numbers of stalks and ears at three different periods :

Average of four parallel pots.

| Soils. | Pots. | Nature of manures and $MnSO_4$ | July 18 | | August 9 | | November 1 | |
|---|---|---|---|---|---|---|---|---|
| | | | Height cm. | No. of stalks. | Height cm. | No. of stalks. | Height cm. | No. of ears. |
| Sandy soil | A | Acidic ... ... ... | 56.7 | 24 | 92.7 | 66 | 113.0 | 61 |
| | A′ | „ +$MnSO_4$... | 58.8 | 24 | 94.8 | 64 | 114.8 | 66 |
| | B | Neutral ... ... ... | 58.8 | 21 | 97.9 | 58 | 114.8 | 56 |
| | B′ | „ +$MnSO_4$... | 59.1 | 21 | 94.2 | 63 | 115.2 | 66 |
| | C | „ ... ... ... | 59.7 | 23 | 98.2 | 65 | 113.0 | 57 |
| | C′ | „ +$MnSO_4$... | 60 3 | 27 | 98.2 | 69 | 118.2 | 63 |
| | D | Alkaline ... ... | 59 7 | 24 | 91.8 | 65 | 119.4 | 60 |
| | D′ | „ +$MnSO_4$... | 63.0 | 28 | 92.4 | 64 | 118.5 | 64 |
| Loamy soil | A | Acidic ... ... ... | 56.7 | 16 | 89.4 | 51 | 112.4 | 79 |
| | A′ | „ +$MnSO_4$... | 58.0 | 21 | 94.8 | 61 | 112.1 | 82 |
| | B | Neutral ... ... ... | 60.0 | 18 | 95.8 | 55 | 113.0 | 81 |
| | B′ | „ +$MnSO_4$ .. | 60.3 | 22 | 95.2 | 60 | 116.4 | 80 |
| | C | „ ... ... ... | 56.1 | 20 | 89.7 | 56 | 112.1 | 84 |
| | C′ | „ +$MnSO_4$... | 57.0 | 22 | 94.2 | 65 | 116.1 | 79 |
| | D | Alkaline ... ... | 58.8 | 20 | 91.2 | 57 | 115.8 | 83 |
| | D′ | „ +$MnSO_4$... | 63.0 | 23 | 91.5 | 57 | 115.8 | 86 |

The adjoining plate XXII shows the development, Oct. 25.

The plants were harvested Nov. 1, and weighed in the air-dry state with the following result, g.:

Average of four parallel pots.

| Soils. | Pots. | Nature of manures and $MnSO_4$ | Grains. | Straw. | Chaffs. | Total. |
|---|---|---|---|---|---|---|
| Sandy soil | A | Acidic ... ... ... | 80.73 | 111.88 | 3.35 | 195.96 |
| | A′ | „ +$MnSO_4$ ... | 85.78 | 118.40 | 3.25 | 207.43 |
| | B | Neutral ... ... ... | 83.90 | 113.10 | 2.68 | 199 68 |
| | B′ | „ +$MnSO_4$ ... | 92.05 | 124.41 | 3.08 | 219.54 |
| | C | Neutral ... ... ... | 83.20 | 113.23 | 2.58 | 199.01 |
| | C′ | „ +$MnSO_4$ ... | 91.52 | 121.25 | 2.90 | 215.67 |
| | D | Alkaline ... ... ... | 90.90 | 117.05 | 3.48 | 211.43 |
| | D′ | „ +$MnSO_4$ ... | 97.45 | 121.93 | 4.33 | 223.71 |
| Loamy soil | A | Acidic ... ... ... | 63.77 | 137.93 | 5.27 | 206.97 |
| | A′ | „ +$MnSO_4$ ... | 66.70 | 140.90 | 3.93 | 211.53 |
| | B | Neutral ... ... ... | 75.33 | 135.55 | 4.90 | 215.78 |
| | B′ | „ +$MnSO_4$ ... | 85.88 | 136.90 | 4.40 | 227.21 |
| | C | Neutral ... ... ... | 85.60 | 130.57 | 4.23 | 220.40 |
| | C′ | „ +$MnSO_4$ ... | 97.50 | 139.23 | 3.88 | 240.61 |
| | D | Alkaline ... ... ... | 85.73 | 133.17 | 3.77 | 222.67 |
| | D′ | „ +$MnSO_4$ ... | 93.10 | 136.20 | 4.20 | 233.50 |

If we now assume the yield of grains of the pots without manganese sulphate in each manurial mixture of each soil respectively to be = 100, we obtain the following ratio:

| Soils. | Pots. | Nature of manures and $MnSO_4$ | Comparative yield of grain. |
|---|---|---|---|
| Sandy-soil. | A | Acidic ... ... ... ... ... ... ... ... | 100 |
| | A′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 106 |
| | B | Neutral ... ... ... ... ... ... ... ... | 100 |
| | B′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 110 |
| | C | Neutral ... ... ... ... ... ... ... ... | 100 |
| | C′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 110 |
| | D | Alkaline ... ... ... ... ... ... ... ... | 100 |
| | D′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 107 |
| Loamy-soil. | A | Acidic ... ... ... ... ... ... ... ... | 100 |
| | A′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 105 |
| | B | Neutral ... ... ... ... ... ... ... ... | 100 |
| | B′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 114 |
| | C | Neutral ... ... ... ... ... ... ... ... | 100 |
| | C′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 114 |
| | D | Alkaline ... ... ... ... ... ... ... ... | 100 |
| | D′ | ,, +$MnSO_4$ ... ... ... ... ... ... | 109 |

From this result, it can be inferred that

1.) The stimulating effect of manganese salt differs to some extent according to the nature of soils. The maximum increase caused by manganese salt amounted to 10 % on sandy soil, while that with the loamy soil reached 14 %.

2.) The stimulating effect of manganese salt also depends upon the nature of the manuring mixture. The maximum yield was observed with the neutral manuring mixtures in each case of soils (B′ and C′).

## B. Stimulating Action of Iodine.[1]

### 1). Experiment with *Panicum miliaceum.*

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Twelve cylinders, each having an area of 1/200000 ha., were filled with 18.75 kilo. air-dry alluvial sand.

The potassium iodide was applied as follows:

| | Per pot, g. | Ratio per ha., g. |
|---|---|---|
| I ... ... ... ... ... ... | Control | 0 |
| II ... ... ... ... ... ... | 0.000047 | 9.4 |
| III ... ... ... ... ... ... | 0.000094 | 18.8 |
| IV ... ... ... ... ... ... | 0.00047 | 94.0 |
| V ... ... ... ... ... ... | 0.00094 | 188.0 |
| VI ... ... ... ... ... ... | 0.00188 | 376.0 |

Each cylinder received June 20 secondary sodium phosphate, potassium sulphate and ammonium sulphate at the rate of 56.3 kilo. $P_2O_5$ and 75 kilo. each of N and $K_2O$ per ha. Three days later, the seeds were sown, and the young shoots later reduced per pot to four of about equal size. Potassium iodide was applied as top-dressing in three fractions, i.e. July 13, 26, and Aug. 3. During vegetation, the treated plants looked more vigorous than the control plants. The plants were harvested on Sept. 5, and weighed in the air-dry state with the following result, g.:

Average of two parallel cylinders.

| Pots. | KI per ha., g. | Grains. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I | 0 | 22 9 | 30.7 | 3.2 | 56.8 | 100 | 100 |
| II | 9.4 | 23.4 | 32.9 | 3.7 | 60.0 | 102 | 106 |
| III | 18.8 | 24.0 | 36.8 | 4 0 | 64 8 | 105 | 114 |
| IV | 94.0 | 24.5 | 38.8 | 3.8 | 67.1 | 107 | 118 |
| V | 188.0 | 26.8 | 39.0 | 4.1 | 69.9 | 117 | 123 |
| VI | 376.0 | 27.7 | 41.0 | 4.2 | 72.9 | 121 | 128 |

1). For the stimulating action of potassium iodide upon sesamum and barley see Bulletin of the Imperial Central Agr. Exper. Stat. Japan, Vol. I, No. I, p. 35.

This result shows that small doses of potassium iodide act favorably on the yield of *Panicum miliaceum*, and that the dose of potassium iodide can be still profitably increased to 376 g. per ha.

2). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of 1/95500 ha. was filled with 26.67 kilo. dry soil, a diluvial loam. Potassium iodide was applied at the rate of

| | | |
|---|---|---|
| I | 0 | per ha. |
| II | 25 g. | |
| III | 50 „ | |
| IV | 100 „ | |
| V | 500 „ | |
| VI | 1 kilo. | |
| VII | 5 „ | |

For each series, ten cylinders were prepared. On Nov. 2, each cylinder received 17.58 g. blood meal, 8.43 g. common superphosphate and 21.5 g. kainit; and again received 30 seeds of six sided barley. The young shoots were later reduced to 20 per pot of about equal size. Dilute solution of potassium iodide was applied as top-dressing in three fractions, i.e. March 19, April 17 and May 1. During vegetation, the plants supplied with potassium iodide looked more vigorous than those of the control cylinders. The following table shows the data regarding the growth observed May 24:

Average of ten parallel cylinders.

| Cylinders. | KI p r ha. | Height cm. | No. of stalks. |
|---|---|---|---|
| I | 0 | 92.7 | 40 |
| II | 25 g. | 93.0 | 41 |
| III | 50 „ | 93.3 | 42 |
| IV | 100 „ | 94.0 | 43 |
| V | 500 „ | 94.8 | 48 |
| VI | 1 kil. | 93.9 | 44 |
| VII | 5 „ | 92.6 | 43 |

The plants were harvested June 8, and weighed in the air-dry state with the following result, g.:

Average of ten parallel cylinders.

| Cylinders | KI per ha. | Grains. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I | 0 | 65.8 | 84.0 | 5.2 | 155 0 | 100 | 100 |
| II | 25 g. | 69.8 | 88.9 | 6.1 | 164.8 | 106 | 106 |
| III | 50 „ | 74.2 | 96.5 | 6.8 | 177.5 | 113 | 115 |
| IV | 100 „ | 77.1 | 97.3 | 7.2 | 181.6 | 116 | 117 |
| V | 500 „ | 87.9 | 112.0 | 7.7 | 207.6 | 134 | 134 |
| VI | 1 kilo. | 81.3 | 101.1 | 6.7 | 189.1 | 124 | 122 |
| VII | 5 „ | 76.6 | 95.5 | 6.9 | 179.0 | 116 | 115 |

This result shows that potassium iodide acts very favorably on the yield of barley, the optimum dose being 500 g. per ha.

### C. Stimulating Action of Fluorine.

#### 1). Experiment with *Panicum Miliaceum.*

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Twelve cylinders, each having an area of 1/200000 ha., were filled with 18.75 kilo. air-dry soil, an alluvial sand. Sodium fluoride was applied as follows:

| | Per pot, g. | Per ha., g. |
|---|---|---|
| I ... ... ... ... ... ... ... ... | Control | 0 |
| II ... ... ... ... ... ... ... ... | 0.000188 | 37.6 |
| III ... ... ... ... ... ... ... ... | 0.00094 | 188.0 |
| IV ... ... ... ... ... ... ... ... | 0.00141 | 282.0 |
| V ... ... ... ... ... ... ... ... | 0.00188 | 376.0 |
| VI ... ... ... ... ... ... ... ... | 0.0047 | 940.0 |

Each cylinders received June 20 secondary sodium phosphate, ammonium sulphate and potassium sulphate at the rate of 56.3 kilo. phasphoric acid and 75 kilo. each of nitrogen and potassa per ha. Three days later, the seeds were sown, and the young shoots afterwards reduced to four per

pot. Sodium fluoride was applied as top-dressing in three fractions, i.e. July 13, 26, and Aug. 3. During vegetation, the treated plants looked more vigorous than the control plants. The plants were harvested Sept. 5, and weighed in the air-dry state with the following result, g.:

Average of two parallel cylinders.

| Pots. | NaF per ha. g. | Grains. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I | 0 | 22.9 | 30.7 | 3.2 | 56.8 | 100 | 100 |
| II | 37.6 | 24.3 | 36.7 | 4.0 | 65.0 | 106 | 114 |
| III | 188.0 | 24.5 | 38.4 | 3.3 | 66.2 | 107 | 117 |
| IV | 282.0 | 27.5 | 39.0 | 3.5 | 70.0 | 120 | 123 |
| V | 376.0 | 29.9 | 41.2 | 5.1 | 76.2 | 131 | 134 |
| VI | 940.0 | 31.7 | 42.5 | 5.2 | 79.4 | 138 | 140 |

This result shows that sodium fluoride acted powerfully on the yield of *Panicum miliaceum*, and that the dose of that salt at the rate of 940 g. per ha. brought the maximum harvest.

2). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of 1/137500 ha. was filled with 15.56 kilo. dry soil, a diluvial loam. Sodium fluoride was applied at the rate of

| | | |
|---|---|---|
| I | ... ... ... ... ... ... ... | 0 |
| II | ... ... ... ... ... ... ... | 250 |
| III | ... ... ... ... ... ... ... | 500 |
| IV | ... ... ... ... ... ... ... | 1000 |
| V | ... ... ... ... ... ... ... | 5000 |

g. per ha.

For each series, ten cylinders were prepared. On Nov. 2, each cylinder received 12.15 g. blood meal, 5.86 g. common superphosphate and 15 g. kainit, and 25 seeds of six side barley. The young plants were afterwards reduced to 15 per pot. Sodium fluoride was applied as top-dressing in three fractions, i.e. March 19, April 17, and May 1.

The plants supplied with sodium fluoride developed better than those of

the control cylinders. The following table shows the data regarding the growth observed at May 24:

Average of ten parallel cylinders.

| Cylinders. | NaF per ha. g. | Height cm. | No. of stalks. |
|---|---|---|---|
| I | 0 | 93.9 | 42 |
| II | 250 | 97.0 | 44 |
| III | 500 | 97.3 | 42 |
| IV | 1000 | 96.4 | 43 |
| V | 5000 | 97.3 | 45 |

The plants were harvested on June 5, and weighed in the air-dry state with the following result, g.:

Average of ten parallel cylinders.

| Cylinders | NaF per ha. | Grains. | Straw. | Chaffs. | Total. | Comparative yield. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Grains. | Total. |
| I | 0 | 63.5 | 78.6 | 4.5 | 147.5 | 100 | 100 |
| II | 250 g. | 68.8 | 83.3 | 5.6 | 157.7 | 108 | 107 |
| III | 500 „ | 70.6 | 84.5 | 5.8 | 160.9 | 111 | 109 |
| IV | 1000 „ | 71.0 | 86.1 | 6.0 | 163.1 | 112 | 111 |
| V | 5000 „ | 74.9 | 92.8 | 6.3 | 174.0 | 118 | 118 |

This result shows that sodium fluoride acted favorably on the yield of barley even at a relatively high dose of 5 kilo. per ha.

## D. Summary of Results.

From the results of our experiments here described, we can draw the following conclusions:

1). Manganese as well as iron stimulates the development of plants. Different plants differ considerably in their susceptibility toward the action of manganese and iron salt. In some cases, the joint application of manganese and iron salt exerts a better effect on the development of plants than when each of these salts is applied alone, while in other cases the opposite results were observed. Generally manganous sulphate was better than ferrous sulphate.

2). The stimulating action of manganese differs greatly with the character of soil.

3). The stimulating action of manganese differs also considerably with the mode of its application. When applied as top-dressing, it gives in general better results than when applied together with the manure.

4). The stimulating action of manganese differs again greatly with the nature of the manurial mixture. A manurial mixture of a nearly neutral reaction, exerts the best effect. Manures of decisive alkaline or acidic nature on the other hand are not so favorable, since the former interferes with the effect of the manganese salt, while the latter are not suitable for the growth of most plants.

5). The amounts of manganese salt to be applied will in generall be sufficient at the rate of 20–50 kilo. of the crystallized sulphate per ha.

6). The following table shows conveniently the stimulating effects of manganese and iron salts under different conditions:

I.) Field Experiments (diluvial loam).

| Crop. | Area of each plot. | Nature of manurial mixture. | Stimulating Compound. | | Percentage increase of Harvest. |
|---|---|---|---|---|---|
| | | | Amount per ha. | Mode of application. | |
| Barley ... ... | 1/100 ha. | Alkaline | 33.2 kilo. $Mn_3O_4$ | top-dressing in 4 portions | 6% grains |
| Wheat ... ... | „ | „ | „ „ | „ „ „ „ „ | 9% „ |
| Upland-Rice ... | 1/300 ha. | „ | 15 kilo. $MnSO_4+4aq.$<br>„ $FeSO_4+7aq.$ | „ „ „ 3 „ | 6% „ |
| Buckwheat ... | 331 sq. meters | „ | 20 kilo. $MnSO_4+4aq.$ | together with manure | 10% „ |
| | | | „ „ | top-dressing in 2 portions | 17% „ |
| Beans ... ... | 1/278 ha. | „ | „ „ | together with manure | 26% „ |
| | | | „ „ | top-dressing in 3 portions | 44% „ |
| Sweet-Potato ... | 1/100 ha. | „ | 15 kilo. „<br>„ $FeSO_4+7aq.$ | „ „ „ „ „ | 35% tubers |

| Crop. | Area of each plot. | Nature of manurial mixture. | Stimulating Compound. Amount per ha. | Mode of application. | Percentage increase of Harvest. |
|---|---|---|---|---|---|
| Sweet-Potato ... | 1/100 ha. | Alkaline | 15 kilo. $FeSO_4+7aq.$ | top-dressing in 3 portions | 21% tubers |
| | | | ,, $MnSO_4+4aq.$ | ,, ,, ,, ,, ,, | 34% ,, |
| Radish ... ... | 1/200 ha. | ,, | 20 kilo. ,, | ,, ,, ,, ,, ,, | 21% roots |
| ,, ... ... | 1/278 ha. | ,, | ,, ,, | together with manure | 4% grains |
| | | | ,, ,, | top-dressing in 3 portions | 8% ,, |
| ,, ... ... | 17.5 sq. meters | ,, | ,, $FeSO_4+7aq.$ | ,, ,, ,, ,, ,, | 26% roots |
| | | | ,, ,, ,, $MnSO_4+4aq.$ | ,, ,, ,, ,, ,, | 29% ,, |
| | | | ,, ,, | ,, ,, ,, ,, ,, | 35% ,, |
| Carrot ... ... | 1/400 ha. | ,, | ,, $FeSO_4+7aq.$ | ,, ,, ,, ,, ,, | 2% ,, |
| | | | ,, ,, ,, $MnSO_4+4aq.$ | ,, ,, ,, ,, ,, | 20% ,, |
| | | | ,, ,, | ,, ,, ,, ,, ,, | 20% ,, |
| *Brassica Campestris, cul. var. Hakusai* ... ... | ,, | ,, | ,, ,, | together with manure | 8% total |
| | | | ,, ,, | top-dressing in 2 portions | 14% ,, |
| ,, ,, | 1/750 ha. | ,, | ,, $FeSO_4+7aq.$ | ,, ,, ,, ,, ,, | 15% ,, |
| | | | ,, ,, ,, $MnSO_4+4aq.$ | ,, ,, ,, ,, ,, | 18% ,, |
| | | | ,, ,, | ,, ,, ,, ,, ,, | 27% ,, |
| *Brassica Campestris cul. var. Mikawashima-Na* ... ... | 1/278 ha. | ,, | ,, ,, | together with manure | 10% ,, |
| | | | ,, ,, | top-dressing in 3 portions | 23% ,, |
| Egg-plant... ... | 1/200 ha. | Acidic | 10 kilo. $Mn_3O_4$ | ,, ,, ,, ,, ,, | 11% fruits |
| Alsic Clover ... | 4.96 sq. meters | Neutral | 25 kilo. $Mn_3O_4$ | ,, ,, ,, ,, ,, | 20% total |
| Red Climping ... | ,, | Alkaline | ,, ,, | ,, ,, ,, ,, ,, | 20% ,, |

| Crop. | Area of each pot. | Nature of manurial mixture. | Stimulating Compound. | | Percentage increase of Harvest. |
|---|---|---|---|---|---|
| | | | Amount per ha. | Mode of application. | |
| Medow Soft-grass | 4.96 sq. meters | Alkaline | 25 kilo. $Mn_3O_4$ | top-dressing in 3 portions | 35% total |
| Tea plant (old)... | 1/375 ha. | „ | 37.5 kilo. „ | „ „ „ „ „ | 29% leaves |
| Young Tea-plant (after second year) | 1/2,250 ha. | „ | 20.3 kilo. $MnSO_4+4aq.$ | „ „ „ 5 „ | 15% total |
| Young Tea-plant (after second year) | „ | Neutral | 12.19 kilo. „ | „ „ „ 3 „ | 18% „ |

## II). Pot Experiments:

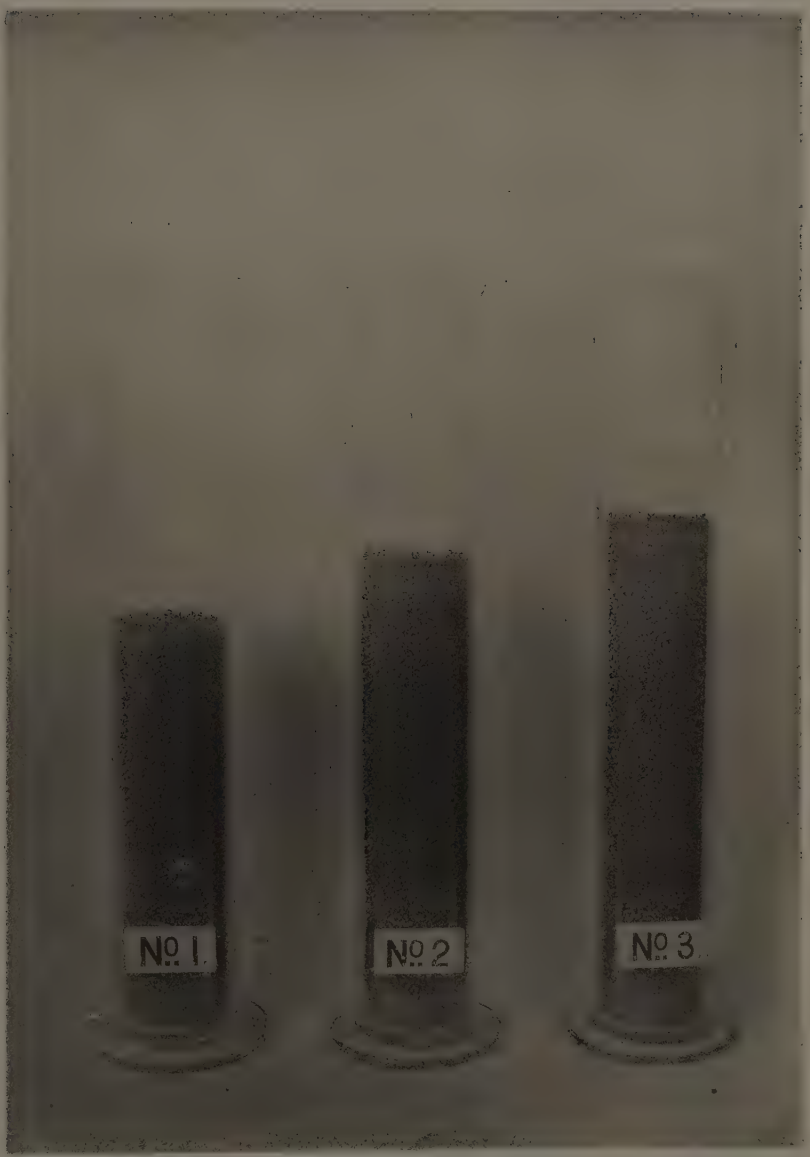
| Crop. | Area of each pot. | Soil. | Nature of manurial mixture. | Stimulating Compound. | | Percentage increase of Harvest. |
|---|---|---|---|---|---|---|
| | | | | Amount per ha. | Mode of application. | |
| Paddy-Rice | 1/200,000 ha. | Alluvial sand | Acidic | 30 kilo. $MnSO_4+4aq.$ | together with mixture | 6% grains |
| | | | Neutral | „ „ | „ „ „ | 10% „ |
| | | | „ | „ „ | „ „ „ | 10% „ |
| | | | Alkaline | „ „ | „ „ „ | 7% „ |
| | | Diluvial loam | Acidic | „ „ | „ „ „ | 5% „ |
| | | | Neutral | „ „ | „ „ „ | 14% „ |
| | | | „ | „ „ | „ „ „ | 14% „ |
| | | | Alkaline | „ „ | „ „ „ | 9% „ |
| Barley | 1/95 500 ha. | „ | Acidic | 10 kilo. $Mn_3O_4$ | top-dressing in 3 portions | 14% „ |
| | | | | 25 kilo. „ | „ „ „ „ „ | 18% „ |
| | | | | 50 kilo. „ | „ „ „ „ „ | 12% „ |
| | | | | 100 kilo. „ | „ „ „ „ „ | 10% „ |
| | | | | 500 kilo. „ | „ „ „ „ „ | 2% „ |
| Buckwheat | 1/18, 180 ha. | „ | Neutral | 20 kilo, $MnSO_4+4aq.$ | „ „ „ 2 „ | 9% „ |

| Crop. | Area of each pot. | Soil. | Nature of manurial mixture. | Stimulating Compound. | | Percentage increase of Harvest. |
|---|---|---|---|---|---|---|
| | | | | Amount per ha. | Mode of application. | |
| Beans. | 1/200,000 ha. | Alluvial sand | Acidic | 20 kilo. $MnSO_4+4aq.$ | together with manure | 51% grains |
| | | | | 200 kilo. „ | „ „ „ | 65% „ |
| | | | | 20 kilo. „ | top-dressing in 5 portions | 58% „ |
| | | | | 200 kilo. „ | „ „ „ „ „ | 28% „ |
| Sesamum | 1/137,500 ha. | Diluvial loam | Alkaline | 41.25 kilo. „ | together with manure | −2% „ |
| | | | | 103.125 kilo. „ | „ „ „ | −2% „ |
| | | | | 206.25 kilo. „ | „ „ „ | 3% „ |
| | | | | 412.5 kilo. „ | „ „ „ | ± |
| „ | 1/137,500 ha. | „ | Acidic | 41.25kilo. $MnSO_4+4aq.$ | „ „ „ | 10% „ |
| | | | | „ „ | top-dressing in 2 portions | 10% „ |
| | | | | 82.5 kilo. „ | „ „ „ 4 „ | 11% „ |
| *Panicum miliaceum* | 1/200,000 ha. | Alluvial sand. | Neutral | 9.4 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+7aq.$ | „ „ „ 3 „ | 9% „ |
| | | | | 18.8 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+7aq.$ | „ „ „ „ „ | 12% „ |
| | | | | 28.2 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+7aq.$ | „ „ „ „ „ | 19% „ |
| | | | | 37.6 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+7aq.$ | „ „ „ „ „ | 17% „ |
| | | | | 75.2 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+7aq.$ | „ „ „ „ „ | 11% „ |
| | | | | 188 kilo. $MnSO_4+4aq.$ + „ $FeSO_4+4aq.$ | „ „ „ „ „ | 2% „ |
| Spinach | „ | Diluvial loam | Alkaline | 40 kilo. $MnSO_4+4aq.$ | together with manure | 2% total |
| | | | | 100 kilo. „ | „ „ „ | 26% „ |
| | | | | 200 kilo. „ | „ „ „ | 33% „ |
| | | | | 400 kilo. „ | „ „ „ | 16% „ |

| Crop. | Area of each pot. | Soil. | Nature of manurial mixture. | Stimulating Compound. | | Percentage increase of Harvest. |
|---|---|---|---|---|---|---|
| | | | | Amount per ha. | Mode of application | |
| Spinach ... | 1/200,000 ha. | Diluvial loam | Acidic | 40 kilo. „ | top-dressing in 2 portions | 29% total |
| | | | | 60 kilo. „ | „ „ „ 3 „ | 30% „ |
| | | | | 40 kilo. „ | together with manure | 6% „ |
| Radish ... | 1/18,180 ha. | „ | Neutral | 30 kilo. „ | top-dressing in 3 portions | 15% roots |
| Hemp ... | 1/13.750 ha. | Alluvial sand | Acidic | 66.6 kilo. „ | „ „ „ 2 „ | 13% stalk |
| | | Diluvial loam | „ | „ „ | „ „ „ „ „ | 15% „ |
| *Polygonum tinctorium* | 1/18.180 ha. | „ | Neutral | 15 kilo. „ | „ „ „ 3 „ | 13% leaves |

7). Different plants differ considerably in their susceptibility toward the stimulating effect of potassium iodide and sodium fluoride. In most cases, 25–500 g. potassium iodide per ha. or 100–1000 g. sodium fluoride per ha. will be proper doses.

Some experiments with manganese, iodine and fluorine compounds will be continued with modification.




Control. $MnSO_4$ together with the Manure. $MnSO_4$ as top-dressing.

*To page 41.*

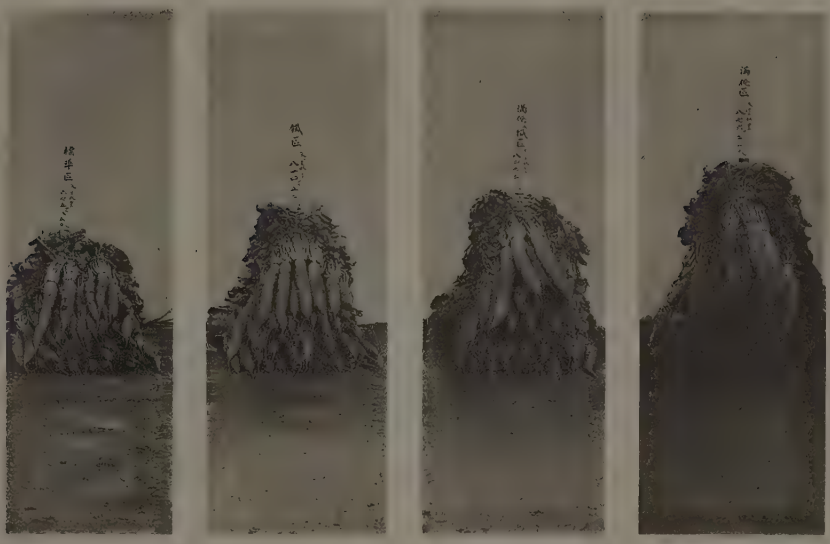
No manure. Manure. Manure + $MnSO_4$.

To page 45.

No manure. Manure. Manure + $MnSO_4$.

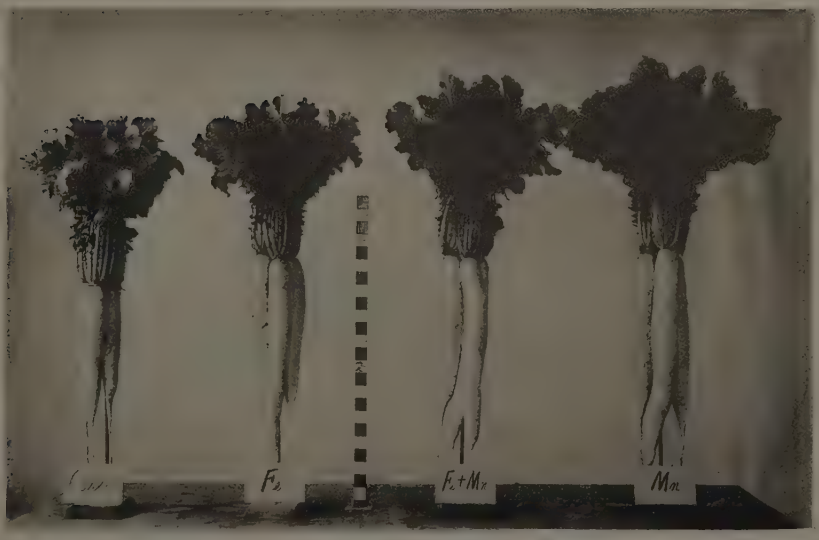
To page 46.

(1)



Control. Fe. Fe+Mn. Mn.

(2)




Control. Fe. Fe+Mn. Mn.

To page 51.

To page 68.

| A | A' | B | B' | C | C' | D | D' |
|---|---|---|---|---|---|---|---|
| Acidic manure. | ditto. + $MnSO_4$. | Neutral manure. | ditto. + $MnSO_4$. | Neutral manure. | ditto. + $MnSO_4$. | Alkaline manure. | ditto. + $MnSO_4$. |

Sandy soil.

To page 68.

| A | A' | B | B' | C | C' | D | D' |
|---|---|---|---|---|---|---|---|
| Acid manure. | ditto. + $MnSO_4$. | Neutral manure. | ditto. + $MnSO_4$. | Neutral manure. | ditto. + $MnSO_4$. | Alkaline manure. | ditto. + $MnSO_4$. |

Loamy Soil.

# On Manuring with Magnesium Sulphate.

BY

**G. DAIKUHARA.**

Manuring with magnesium compounds will be necessary in all such cases where lime exceeds to any great extent the amount of magnesia in soils, and the application of magnesia must be more heavy in cases where cereals are to be grown than for leguminous crops, buckwheat, cruciferous plants, &c. The simplest method would seem to be to add finely powdered magnesit to the soil. But since this material is found only in a few countries in large deposits and is very difficult to pulverize to the necessary degree of fineness, and further, since artificial magnesium carbonate and burnt magnesia are rather too expensive, there remains as the only thing suitable, magnesium compound, the crystallized sulphate of commerce. Of this salt much less would be required than of magnesit as we have formerly pointed out. Our experiments with barley and rice in sand culture have shown that 4.8 resp. 9.6 parts of that sulphate are as effective as 100 parts magnesit. In a loamy humus soil from Komaba this ratio was found to be as 14 : 100,[1] while in a clay soil rich in zeolites this ratio was 23 : 100.[2]

In cases where a heavy manuring with magnesit would be necessary, it would, however, be impractical and too expensive to add the calculated big dose of magnesium sulphate to the whole soil, because not only the sulphate but also the exceedingly fine precipitates it yields in the soil (phosphate, silicate, humate, carbonate, &c.) would after a few years have passed considerably into the drainage water and would be lost. It is therefore a

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1). Bul. Coll. Agr., Imp. Univ. Tokio, Vol. VII, No. 1, p. 63.

2). See Nakamura's article in this Bulletin Vol. I, No. 1.

much better plan to apply magnesium sulphate only as top dressing, because in this way much smaller quantities are required. This top dressing of course has to be repeated annually. It was however necessary to study the question as to how much magnesium sulphate in form of top dressing would be of the same effect as a given quantity of the salt in the general manure.

The loamy humus soil[1] of our experimental farm served for this experiment. The soil was mixed with 4 % of air slaked lime containing 67.4 % CaO and 4.4 % MgO, thus the soil was too rich in lime and this would have required for the maximum crop of barley 1.161 g MgO= 2.333 g magnesit.

I have instituted two series of experiments, in one of which the magnesium sulphate was applied before sowing while in the other as top dressing. Seventeen large zinc cylinders put in the soil and containing 45.4 Kg soil served for these experiments. The amount of $MgSO_4.7H_2O$ applied to each cylinder varied as follows:

I Series.

(Mixed with the whole soil before sowing).

| No. of cylinders. | Amount of $MgSO_4.7H_2O$ p. cyl | Ratio of MgO applied, to 1000 pts calculated amount of MgO as magnesit. | Agronomical Equivalent of $MgSO_4.7H_2O$, magnesit taken as 100. |
|---|---|---|---|
| I. | 56.3 g | 8 | 2.4 |
| II. | 225.0 g | 32 | 9.6 |
| III. | 450.0 g | 64 | 18.2 |

1). This soil contained 0.374 % CaO and 0.412 % MgO in air dry state.

II Series. (Top dressing).[1]

| No. of cylinders. | Amount of $MgSO_4.7H_2O$ p. cyl. | Ratio of MgO applied, to 1000 pts calculated amount of MgO as Magnesit. | Agronomical Equivalent of $MgSO_4.7H_2O$, magnesit taken as 100. |
|---|---|---|---|
| I. | 22.5 g | 3.2 | 0.96 |
| II. | 37.5 g | 5.3 | 1.60 |
| III. | 56.3 g | 8.0 | 2.40 |
| IV. | 112.5 g | 16.0 | 4.80 |

The general manure was:

$NaNO_3$ ... ... ... ... ... ... ... ... ... ... 17.0 g
$(NH_4)_2SO_4$ ... ... ... ... ... ... ... ... ... ... 13.2 g } in 3 fractions.
$Na_2HPO_4$ ... ... ... ... ... ... ... ... ... ... 20.0 g
$K_2SO_4$ ... ... ... ... ... ... ... ... ... ... 20.0 g

On Nov. 5, 1905, 92 seeds p. cylinder of barley (*var. Goldenmelon*) were sown and after the young plants had reached a height of about 5–6 cm. they were reduced to 70 of equal size. The development in the following spring may be seen from the photographs taken June 5, 1906, and reproduced on Plate XXIII. The plants were cut June 5, 1906 and weighed in the air dry state with the following results:

I Series.

| No. of cylinders. | Amount of $MgSO_4.7H_2O$ p. cyl. | Weight of seeds. g | | Weight of straw. g | | Total yield. g | |
|---|---|---|---|---|---|---|---|
| | | p. cyl. | Average. | p. cyl. | Average. | p. cyl. | Average. |
| I. | 56 3 g | 179.3<br>213.4 | 196.3 | 301.5<br>315.4 | 308.5 | 480.8<br>526.2 | 504.8 |
| II. | 225.0 g | 243.7<br>238.5 | 242.1 | 328.5<br>331.1 | 329.8 | 572.3<br>569.6 | 571.0 |

1). 1/3 of $MgSO_4.7H_2O$ was applied before sowing and remaining 2/3 in two fractional top dressings.

| No. of cylinders. | Amount of $MgSO_4.7H_2O$ p. pot. | Weight of seeds. g | | Weight of straw. g | | Total yield. g | |
|---|---|---|---|---|---|---|---|
| | | p. cyl. | Average. | p. cyl. | Average. | p. cyl. | Average. |
| III. | 450.0 g | 265.9<br>194.6 | 230.3 | 288.4<br>359.6 | 324.0 | 554.3<br>554.3 | 554.3 |
| IV. | Control | 213.0<br>208.5<br>188.3 | 203.3 | 275.3<br>288.8<br>303.4 | 289.2 | 488.3<br>497.3<br>491.6 | 492.4 |

## II Series.

| No. of cylinders. | Amount of $MgSO_4.7H_2O$ p. cyl. | Weight of seeds. g | | Weight of straw. g | | Total yield. g | |
|---|---|---|---|---|---|---|---|
| | | p. cyl. | Average. | p. cyl. | Average. | p. cyl. | Average. |
| I. | 22.5 g | 260.1<br>184.5 | 222.3 | 364.5<br>339.4 | 352.0 | 624.6<br>523.9 | 574.3 |
| II. | 37.5 g | 202.2<br>232.1 | 217.2 | 304.9<br>335.3 | 320.1 | 507.1<br>567.4 | 537.3 |
| III. | 56.3 g | 182.3<br>202.9 | 192.6 | 315.8<br>322.9 | 319.4 | 498.0<br>525.8 | 511.9 |
| IV. | 112.5 g | 138.9<br>232.5 | 185.7 | 270.0<br>303.0 | 286.5 | 408.9<br>535.5 | 472.2 |
| V. | Control | 213.0<br>208.5<br>188.3 | 203.3 | 275 3<br>288.8<br>303.4 | 289.2 | 488.3<br>497.3<br>491.6 | 492.4 |

The results show that in our soil when crystallized sulphate of magnesia was applied before sowing mixing with the whole soil, the best result was obtained with ratio of 32 parts MgO as $MgSO_4.7H_2O$ to 1000 parts of the calculated amount of MgO as magnesit, while with top dressing just 1/10 of

MgO as $MgSO_4.7H_2O$ was sufficient for the same effect. In other words, ca. 10 parts of the crystallized magnesium sulphate is as effective as 100 parts of pulverized magnesit in the former case while 1 part of that salt has the same effect in the case of top dressing.

A second experiment with barley was carried out on the same soil and with the same cylinders, after overliming it with 5 % air slaked lime. In this case however no comparison with top dressing with $MgSO_4.7H_2O$ was made. Four weeks afterwards[1] 413.4 g $MgSO_4.7H_2O$ were mixed with the whole soil before sowing, thus corresponding to the ratio of

$$MgSO_4.7H_2O : \text{magnesit} = 14 : 100$$

The general manure, time of sowing and cutting were the same as in the former experiments.

The following results were obtained:

| | Average length of plants. | Number of stalks. | Weight in the air dry state. g | | |
|---|---|---|---|---|---|
| | | | Seeds. | Straw. | Total. |
| Control ... ... | 81.8 cm. | 162 | 213.8 | 239.6 | 453.4 |
| Overlimed ... | 85.2 cm. | 167 | 162.4 | 271.1 | 433.5 |
| Overlimed + $MgSO_4.7H_2O$.. | 88.5 cm. | 198 | 193.9 | 288.4 | 482.3 |

## CONCLUSION.

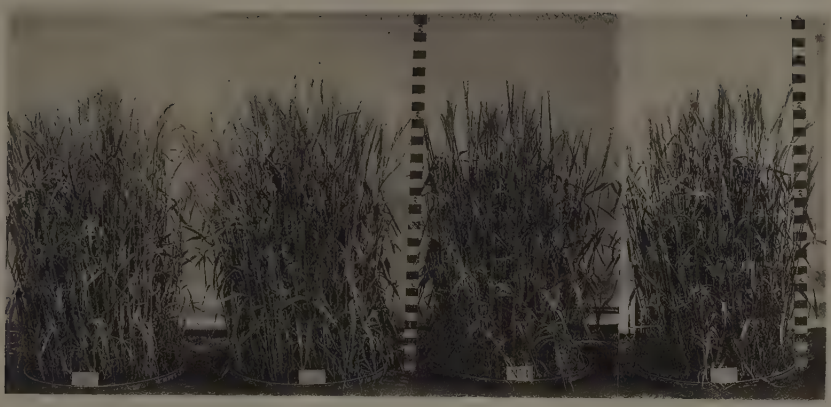
(1). The cheapest and the most effective magnesium compound for the regulation of the lime factor in a soil very rich in lime is the crystallized sulphate.

(2). The most effective method of application of the magnesium sulphate is the top dressing, repeated annually in small doses.

1). Attention must be paid to the fact that in such experiments the slaked lime should be transformed completely into carbonate before the magnesium sulphate is added.

(3). The agronomical equivalent on loamy humus soil like ours for $\bar{M}gSO_4.7H_2O$ is=10, i.e. 10 parts of this salt are as effective as 100 parts of the finest powdered magnesit, when applied before sowing mixed with the whole soil, while in the form of top dressing the equivalent would be reduced to 1, i.e. 1 part of that sulphate has under this condition the same effect as 100 parts of magnesit.

## I. Series.



450g. 225g. 56.3g. control.

$MgSO_4.7H_2O$ mixed with whole soil. overlimed.

## II. Series.

112.5g. 56.3g. 37.5g. 22.5g.

$MgSO_4.7\ H_2O$ applied as top dressing.

# On the Influence of Solubility on Availability.

BY

G. DAIKUHARA.

Various former experiments carried out in Komaba and Nishigahara have shown that for several Gramineae the best ratio of lime to magnesia lies between 1/1 and 2/1. With oats the yield was nearly equal in both cases while with upland rice the ratio 1/1 was more favorable than 2/1 and for barley before its flowering period 2/1 was more favorable. With the development of seed, however, relatively more magnesia is required and also in the case of barley the final ratio will be nearer to 1/1 than 2/1. These ratios, however, correspond to equal availability of lime and magnesia, both having been applied as natural carbonates or as nitrates. The ratio of lime to magnesia entering the plant changes, however, very considerably when one of the compounds is insoluble in water while the other is soluble. The latter will then much more readily enter into the plant body than the former.

My former experiment[1] with rice showed that with artificial carbonate of lime and with magnesia as cryst. sulphate, the best ratio in sand culture was $\frac{\text{CaO as carbonate}}{\text{MgO as sulphate}} = \frac{30}{1}$.

I have carried out a similar experiment with barley in sand culture, applying the lime in the form very finely powdered lime stone. Each pot contained 4.5 Kg of dry sand and received the following general manure applied in five fractions:

| | |
|---|---|
| $NaNO_3$ ... ... ... ... ... ... ... ... ... ... ... ... ... | 10 Gr. |
| $K_2SO_4$ ... ... ... ... ... ... ... ... ... ... ... ... ... | 10 Gr. |
| $KH_2PO_4$ ... ... ... ... ... ... ... ... ... ... ... ... ... | 1.5 Gr. |

While the amount of lime was constant that of magnesia was varied as follows:

1). This Bulletin Vol. I, No. 1, p. 23–29.

| No. of pots. | CaO : MgO | Powdered lime stone. | $MgSO_4+7H_2O$. |
|---|---|---|---|
| I. | 5 : 1 | 80.4 g | 54.96 g |
| II. | 10 : 1 | „ „ | 27.48 „ |
| III. | 20 : 1 | „ „ | 13.74 „ |
| IV. | 30 : 1 | „ „ | 9.16 „ |
| V. | 40 : 1 | „ „ | 6.87 „ |
| VI. | 50 : 1 | „ „ | 5.50 „ |
| VII. | 60 : 1 | „ „ | 4.58 „ |
| VIII. | 70 : 1 | „ „ | 3.44 „ |

The seeds of barley (*var. Goldenmelon*) were sown Nov. 10, 1904 and after germination the young plants were reduced to 6 of equal size. The growth in all the pots started equally well but gradually differences appeared, plants in No. I and II were far inferior in growth while the plants in No. VII and VIII were of the most luxurient development as shown by the following measurements made on Jan. 9, 1905. In the beginning of February the plants in pots No. 1 died off.

Table I.

| No. of Pots. | CaO : MgO. | Average length of the longest leaves. | Average number of stalks p. pot. |
|---|---|---|---|
| I. pot 1 | 5 : 1 | 9.5 cm. | 1 |
| I. pot 2 | | 9.0 „ | 1 |
| II. pot 1 | 10 : 1 | 10.5 „ | 1.8 |
| II. pot 2 | | 10.5 „ | 2.2 |
| III. pot 1 | 20 : 1 | 18.1 „ | 3.8 |
| III. pot 2 | | 18.8 „ | 3.8 |
| IV. pot 1 | 30 : 1 | 20.1 „ | 4.2 |
| IV. pot 2 | | 20.1 „ | 4.5 |
| V. pot 1 | 40 : 1 | 20.6 „ | 5.0 |
| V. pot 2 | | 21.7 „ | 5.3 |

| No. of Pots. | CaO : MgO. | Average length of the longest leaves. | Ayerage number of stalks p. pot. |
|---|---|---|---|
| VI. pot 1 | 50 : 1 | 23.2 cm. | 5.9 |
| VI. pot 2 | | 23.3 „ | 5.8 |
| VII. pot 1 | 60 : 1 | 23.2 „ | 6.8 |
| VII. pot 2 | | 26.0 „ | 6.8 |
| VIII. pot 1 | 80 : 1 | 24.9 „ | 6.9 |
| VIII. pot 2 | | 24.3 „ | 6.9 |

The plants were cut on June 10, dried and weighed with the following result, to which are added the observation on the plants in pot No. I; these died in February.

Table II.

| No. of pots. | CaO : MgO | Number of stalks. | | Number of ears. | | Aver. length of stalks | |
|---|---|---|---|---|---|---|---|
| | | p. pot. | Average. | p. pot. | Average. | of each pot | Average. |
| I. pot 1 | 5 : 1 | 10 | 9 | ... | ... | 9 0 | 8.5 |
| I. pot 2 | | 8 | | ... | | 7.5 | |
| II. pot 1 | 10 : 1 | 19 | 22 | ... | 5 | 45.0 | 45.9 |
| II. pot 2 | | 25 | | 5 | | 46.8 | |
| III. pot 1 | 20 : 1 | 43 | 42.5 | 43 | 41 | 96.0 | 96.0 |
| III. pot 2 | | 42 | | 39 | | 96.0 | |
| IV. pot 1 | 30 : 1 | 41 | 41.0 | 40 | 41 | 96.0 | 99.5 |
| IV. pot 2 | | 41 | | 41 | | 102.9 | |
| V. pot 1 | 40 : 1 | 36 | 45 0 | 35 | 44 | 102.0 | 99.3 |
| V. pot 2 | | 54 | | 52 | | 96.6 | |
| VI. pot 1 | 50 : 1 | 48 | 48.0 | 48 | 46 | 97.5 | 94.8 |
| VI. pot 2 | | 48 | | 43 | | 92.1 | |

| No. of pots. | CaO : MgO | Number of stalks. | | Number of ears. | | Aver. length of stalks. | |
|---|---|---|---|---|---|---|---|
| | | p. pot. | Average. | p. pot. | Average. | of each pot | Average. |
| VII. pot 1 | 60 : 1 | ...[1] | 50.0 | ... | 47 | ... | 97.5 |
| VII. pot 2 | | 50 | | 47 | | 97.5 | |
| VIII. pot 1 | 80 : 1 | 51 | 49.5 | 51 | 49 | 93.0 | 95.9 |
| VIII. pot 2 | | 48 | | 47 | | 98.7 | |

## Table III.

| No. of pots. | CaO : MgO | Seeds g | Stalks g | Chaff g | Root g | Total g | Average p. pot g | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Seeds | Total |
| I. pot 1 | 5 : 1[2] | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| I. pot 2 | | ..... | ..... | ..... | ..... | ..... | | |
| II. pot 1 | 10 : 1[2] | ..... | 13.50 | ..... | 1.88 | 15.38 | 0.38 | 26.26 |
| II. pot 2 | | 0.38 | 28.88 | 0.38 | 7.50 | 37.14 | | |
| III. pot 1 | 20 : 1 | 18.38 | 79.50 | 4.50 | 15.75 | 118.13 | 25.69 | 128.26 |
| III. pot 2 | | 33.00 | 82.88 | 3.75 | 18.75 | 138.38 | | |
| IV. pot 1 | 30 : 1 | 29.63 | 82.50 | 6.00 | 18.13 | 136.26 | 31.51 | 135.45 |
| IV. pot 2 | | 33.38 | 81.00 | 4.13 | 16.13 | 134.64 | | |
| V. pot 1 | 40 : 1 | 25.13 | 72.38 | 3.75 | 16.50 | 117.76 | 20.26 | 144.39 |
| V. pot 2 | | 15.38 | 121.50 | 4.88 | 29.25 | 171.01 | | |
| VI. pot 1 | 50 : 1 | 24.75 | 104.63 | 6.00 | 15.00 | 150.38 | 26.82 | 144.58 |
| VI. pot 2 | | 28.88 | 92.63 | 4.13 | 13.13 | 138.77 | | |

1). Some plants in this pot were attacked by fungus and cut off before ripening.

2). In these two cases it is very probable that not only a certain excess of available magnesia, but also the salt concentration itself, caused the depression of the yield. All soluble salts, though not directly injurious to the plant, would perhaps cause the depression when applied in such concentration.

| No. of pots. | CaO : MgO | Seeds g | Stalks g | Chaff g | Root g | Total g | Average p. pot g Seeds. | Average p. pot g Total. |
|---|---|---|---|---|---|---|---|---|
| VII. pot 1 | 60 : 1 | ..... | ..... | ..... | ..... | ..... | 52.13 | 159.01 |
| VII. pot 2 | | 52.13 | 88.88 | 6.00 | 12.00 | 159.01 | | |
| VIII. pot 1 | 80 : 1 | 40.50 | 98.25 | 6.38 | 18.00 | 163.13 | 41.63 | 157.70 |
| VIII. pot 2 | | 42.75 | 91.50 | 4.88 | 13.13 | 152.26 | | |

The above result shows clearly that in the presence of lime as carbonate, the necessary amount of magnesia applied in the form of crystallized sulphate for barley in sand culture is so small that the best ratio of lime to magnesia becomes 60 : 1, while in the form of nitrates of calcium and magnesium in water culture the best ratio for Gramineae between 1/1 and 2/1. This conclusion will hold good also for various sandy soils, while for clayey soils the best ratio is $\frac{\text{CaO as carbonate}}{\text{MgO as sulphate}}$ will differ, as T. NAKAMURA[1] ascertained. The calculation from the above results shows that with barley 4.9 parts $MgSO_4.7H_2O$ are agronomically equivalent to 100 parts magnesite, while with rice this equivalent is still higher viz. 9.8.

1). This Bulletin Vol. I, No. 1, P. 30–34.

# On the Manurial Effect of Calcium Cyanamide under Different Conditions.

BY

S. UCHIYAMA.

Various reports on the efficacy of Calcium cyanamide or lime-nitrogen (Kalkstickstoff) testify in favor of this compound, its action reaching about that of ammonium sulphate or sodium nitrate; other reports again contain a less favorable declaration. Evidently the nature of the soil and the nature of the other manuring compounds used along with it, have a decided influence upon the result.[1] This difference of opinion can not surprise us, since the reports on the comparative efficacy of sodium nitrate and ammonium sulphate differ also very considerably. Under certain conditions, ammonium sulphate was found equal and even superior to sodium nitrate; under other conditions again inferior to this.

The publications on the new manure show among other things, that it can not be used for top-dressing and that it must be applied some time before sowing, as it would act injuriously before its decomposition by soil-bacteria, liberating its nitrogen as ammonia, is accomplished.

Since however the manurial effect of lime-nitrogen has not yet been compared with those of ammonium sulphate and sodium nitrate under conditions of different reaction of the total manure, it seemed to me of special interest to carry on some experiments along this line. Since lime-nitrogen can be decomposed by various kinds of bacteria into calcium carbonate and ammonia, $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$ it must be defined

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1). Compare especially the publications of B. Schulze, Feilitzen, Roessler, Seelhorst, Strohmer, Stutzer and Aso.

as an alkaline manure, while ammonium sulphate is defined as a physiologically acid nitrogenous manure. Since the ammonia formed by the decomposition of lime-nitrogen will of course rapidly be transformed into carbonate, the question as to which is the best source of nitrogen would be simplified to this: *Under which conditions is ammonium carbonate better than ammonium sulphate or sodium nitrate?*

Kossowitch as well as Prianishnikow have demonstrated recently the injury by too alkaline or too acid reactions. Also here at this stations as well as at the college of agriculture at Komaba near Tokyo similar observations have been made at about the same time. Thus it was observed by myself that ammonium sulphate in conjunction with secondary sodium phosphate produced a much better yield with *Brassica chinensis* than when the former was applied in conjunction with superphosphate. Since lime-nitrogen is an actually alkaline manure, an addition of an acid phosphatic manure would act here favorably—just the opposite from ammonium sulphate.

The sample of lime-nitrogen at my disposal contained 18.58 % N and 56.16 % CaO; the ammonium sulphate[1]=20.65 % N; the crude potassium sulphate=47.55 % $K_2O$; the double superphosphate=40.42 % $P_2O_5$ soluble in water; and the secondary sodium phospate was the pure preparation.

## I. Experiment with *Hordeum sativum.*

Eighteen porcelain pots (area=1/200,000 ha.) were filled each with 14.27 kilo. fresh alluvial loam poor in humus, and received the following manures:

A
- 8.752 g. ammonium sulphate
- 4.60 g. double superphosphate
- 3.91 g. potassium sulphate
- 8.44 g. sodium sulphate

B
- 8.752 g. ammonium sulphate
- 9.38 secondary sodium phosphate
- 3.91 g. potassium sulphate

1). The ammonium sulphate in this experiment was the pure preparation.

C { 10.0 g. lime-nitrogen
4.6 g. double superphosphate
3.91 g. potassium sulphate
8.44 g. sodium sulphate

D { 10.0 g. lime-nitrogen
9.38 g. secondary sodium phosphate
3.91 g. potassium sulphate

Of these four mixtures, A was decidedly acid, D decidedly alkaline, while B and C approached the neutral reaction. Further, in order to provide the pots A and B with as much lime as was contained in the lime-nitrogen, 17.27 g, gypsum were added to these pots on Sept. 7. Gypsum was selected in order not to change chemically the ammonium sulphate; and in order to observe here at the same time the difference in action between gypsum and limestone, two other pots A′ and B′ were prepared in which the equivalent amount of powdered limestone was added on Sept. 7. By this addition, perhaps a little of ammonium sulphate was gradually transformed into ammonium carbonate, the same product which also would be the active principle in the pots C and D. While ammonium carbonate in high dilution is probably more favorable than ammonium sulphate, some loss of this compound by volatilization may take place from soils of little absorptive power, so that the benefit produced in one respect may be frustrated by a disadvantage in another. The following table shows the manuring data, g:

| Manure. | A | A′ | B | B′ | C | D |
|---|---|---|---|---|---|---|
| Ammonium sulphate ... ... | 8.752 | ditto | ditto | ditto | —— | —— |
| Lime-nitrogen ... ... ... ... | —— | —— | —— | —— | 10.0 | ditto |
| Double superphosphate ... ... | 4.60 | ditto | —— | —— | 4.60 | —— |
| Secondary sodium phosphate... | —— | —— | 9.38 | ditto | —— | 9.38 |
| Potassium sulphate... ... ... | 3.91 | ditto | ditto | ditto | ditto | ditto |
| Sodium sulphate ... ... ... | 8.44 | ditto | —— | —— | 8.44 | —— |
| Gypsum ... ... ... ... ... | 17.27 | —— | 17.27 | —— | —— | —— |
| Lime-stone ... ... ... ... | —— | 10.03 | —— | 10.03 | —— | —— |

On Nov. 13, 1905, lime-nitrogen was applied. The pots were kept in a warm house and well moistened in order to accelerate the decomposition of lime-nitrogen. After a week, the other manures were applied. Hence each pot contained 1.858 g N, 1.858 g $P_2O_5$, 1.859 g $K_2O$, 1.626 g $Na_2O$, and 5.618 g CaO.

On Nov. 21, twenty seeds of sixsided barley were sown per pot. After three weeks, the young plants were reduced to 15 per pot of about equal size. The following table shows the height of the plants and number of stalks at two different periods; and the photograph (Plate XXIV, Fig. 1) the development on May 15.

Average of three parallel pots.

| N-Manure. | Group. | Jan. 17. | | May 24. | |
|---|---|---|---|---|---|
| | | Height (Cm.). | No. of stalks. | Height (Cm.) | No. of stalks. |
| $(NH_4)_2SO_4$ | A | 13.7 | 32 | 97.3 | 53 |
| | A' | 14.2 | 30 | 104.8 | 53 |
| | B | 13.9 | 32 | 98 2 | 51 |
| | B' | 12.4 | 26 | 99.7 | 50 |
| $CaCN_2$ | C | 13.9 | 39 | 102.4 | 50 |
| | D | 13.3 | 31 | 98.5 | 50 |

The plants were harvested June 3:

Harvest, average of three parallel pots; air-dry, g.

| N-Manure. | Group. | Grains. | Straw. | Chaffs. | Total. | Comparative yield total. |
|---|---|---|---|---|---|---|
| $(NH_4)_2SO_4$ | A | 62.40 | 79.63 | 4.83 | 146.86 | 107 |
| | A' | 48.20 | 87.00 | 6.50 | 141.70 | 103 |
| | B | 58.77 | 84.57 | 5.20 | 148.54 | 108 |
| | B' | 51.53 | 86.67 | 4.60 | 142.80 | 104 |
| $CaCN_2$ | C | 56.00 | 87.40 | 4.85 | 148.25 | 108 |
| | D | 48.50 | 83.73 | 5.30 | 137.53 | 100 |

It is therefore clear that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words, *the neutral mixture* (*C*) *was better than the alkaline mixture* (*D*). The manuring effect of lime-nitrogen in C was here equal to that of ammonium sulphate in B, when this was applied in conjunction with sodium phosphate.

## II. Experiment with *Brassica Chinensis*.

The soil was an alluvial loam, almost free of humus. Eighteen porcelain pots (area = 1/200,000 ha.) were filled each with 14.27 kilo. of the fresh soil, and manured[1] as follows, g:

| Manure. | A | A′ | B | B′ | C | D |
|---|---|---|---|---|---|---|
| Ammonium sulphate ... ... | 12.0 | ditto. | ditto. | ditto. | — | — |
| Lime-nitrogen... ... ... ... | — | — | — | — | 13.34 | ditto. |
| Double superphosphate ... ... | 2.2 | ditto. | — | — | 2.2 | — |
| Secondary sodium phosphate... | — | — | 4.5 | ditto. | — | 4.5 |
| Potassium sulphate... ... ... | 5.2 | ditto. | ditto. | ditto. | ditto. | ditto. |
| Sodium sulphate ... ... .... | 4.05 | ditto. | — | — | 4.05 | — |
| Gypsum ... ... ... ... ... | 23.03 | — | 23.03 | — | — | — |
| Lime-stone ... ... ... ... | — | 13.38 | — | 13 38 | — | — |

Each pot contained therefore 2.478 g. N, 0.89 g. $P_2O_5$, 2.473 g. $K_2O$, 0.78 g. $Na_2O$, and 7.493 g. CaO.

Twenty seeds of *Brassica chinensis* were sown per pot Sept. 29. After two weeks, the plants were reduced to seven per pot of about equal size. The length and number of leaves on Nov. 7 were as follows:

1). To the corresponding pots, the lime-nitrogen, gypsum, and lime-stone were applied Sept. 7, the phosphatic manures a week later, and the other manures were applied still a week later, in solution.

Average of three parallel pots.

| N-Manure. | Group. | Length (cm.). | No. of leaves. |
|---|---|---|---|
| $(NH_4)_2SO_4$ | A | 23.3 | 61 |
| | A′ | 20.7 | 58 |
| | B | 22.1 | 57 |
| | B′ | 22 5 | 57 |
| $CaCN_2$ | C | 23.9 | 56 |
| | D | 21.8 | 56 |

The adjoining Plate XXIV, Fig. 2 shows the state of development at that time.

The plants were harvested Nov. 13 with the following result, g.:

Average of three parallel pots.

| N-Manure. | Group. | Fresh state. | | | Air-dry state. | | |
|---|---|---|---|---|---|---|---|
| | | Leaves. | Roots. | Total. | Leaves. | Roots. | Total. |
| $(NA_4)_2SO_4$ | A | 169.2 | 9.0 | 178.2 | 18.2 | 1.3 | 19.5 |
| | A′ | 156.3 | 8.2 | 164.5 | 17.7 | 1.1 | 18.8 |
| | B | 182.8 | 10.2 | 193.0 | 20.2 | 1.4 | 21.6 |
| | B′ | 173.3 | 8.8 | 182.1 | 19.1 | 1.2 | 20.3 |
| $CaCN_2$ | C | 177.4 | 11.7 | 189.1 | 19.7 | 1.5 | 21.2 |
| | D | 155.6 | 10.5 | 166.1 | 17.4 | 1.3 | 18.7 |

If we now assume the total yield (in the air-dry state) of the pots D to be = 100, we obtain the following ratio:

| N-Manure. | Group. | Comparative yield. |
|---|---|---|
| $(NH_4)_2SO_4$ | A | 104 |
| | A′ | 101 |
| | B | 116 |
| | B′ | 109 |
| $CaCN_2$ | C | 113 |
| | D | 100 |

The result shows that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words: *the neutral mixture (C) was better than the alkaline mixture (D)*. The physiologically acid ammonium sulphate acted however better with sodium phosphate (B) than with superphosphate (A); also this result leads to the inference: *the neutral reaction of the total manure in B* was more favorable than the *acidic reaction in A*.

The moderate dose of calcium carbonate in A′ and B′ was of no special effect in connection with the ammonium sulphate, but this can be easily understood, because the soil contained already some carbonate of lime.

## III. Second Experiment with *Brassica Chinensis*.

*The amount of nitrogen was here diminished to one third* of that in the preceding experiment, and two different kinds of soils[1] i.e. diluvial loamy and alluvial sandy soils served for the test. Forty eight zinc pots (area= 1/200,000 ha.) were filled with the respective soils (15.75 kilo. per pot). Twelve series were prepared, each consisting of four pots. To the respective pots, the following manures were applied, g:

1). The loamy soil from the upland of our station is very rich in humus, while the sandy soil from the paddy field of Kawaguchi near Tokyo is almost free from organic matter.

| Manure. | A | A′ | B | B′ | C | D |
|---|---|---|---|---|---|---|
| Ammonium sulphate ... ... | 4.0 | ditto. | ditto. | ditto. | — | — |
| Lime-nitrogen ... ... ... ... | — | — | — | — | 4.45 | ditto. |
| Double superphosphate ... ... | 2.2 | ditto. | — | — | 2.2 | — |
| Secondary sodium phosphate... | — | — | 4.5 | 4.5 | — | 4.5 |
| Potassium sulphate... ... ... | 4.0 | ditto. | ditto. | ditto. | ditto. | ditto. |
| Sodium sulphate ... ... ... | 4.05 | ditto. | — | — | 4.05 | — |
| Gypsum ... ... ... ... ... | 7.68 | — | 7.68 | — | — | — |
| Lime-stone ... ... ... ... | — | 4.46 | — | 4.46 | — | — |

On December 25, lime-nitrogen was applied, while four months later the other manuring ingredients. Hence each pot contained 0.83 g. N, 0.89 g. $P_2O_5$, 1.90 g. $K_2O$, 0.78 g. $Na_2O$ and 2.50 g. CaO. On April 11, twenty seeds of *Brassica Chinensis* were sown per pot. The young plants appeared five days later in all pots with the loamy soil, while the germination in all pots with the sandy soil commenced two days later. On April 25, the young plants were thinned to eight of about equal size.

During vegetation, the plants of the pots B in both series seemed most luxuriant. The following table shows the average length of leaves measured on May 21 :

Averaged of four parallel pots.

| Soil. | N-Manure | Group. | Length (cm.). |
|---|---|---|---|
| Loamy soil | $(NH_4)_2SO_4$ | A | 26.1 |
| | | A′ | 25.2 |
| | | B | 28.8 |
| | | B′ | 27.9 |
| | $CaCN_2$ | C | 25.2 |
| | | D | 26.1 |

| Soil. | N-manure. | Group. | Length (cm.). |
|---|---|---|---|
| Sandy soil | $(NH_4)_2SO_4$ | A | 28.2 |
| | | A′ | 27.0 |
| | | B | 27.6 |
| | | B′ | 27.3 |
| | $CaCN_2$ | C | 22.7 |
| | | D | 21.5 |

The plants were harvested May 21 with the following result, g. :

Average of four parallel pots.

| Soil. | N-manure. | Group. | Fresh state. | | | Air-dry state. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Leaves. | Roots. | Total. | Leaves. | Roots. | Total. |
| Loamy soil | $(NH_4)_2SO_4$ | A | 192.06 | 11.90 | 203.96 | 22.98 | 1.50 | 24.48 |
| | | A′ | 188.55 | 12.20 | 200.75 | 22.53 | 1.35 | 23.88 |
| | | B | 217.38 | 14.25 | 231.63 | 24.33 | 1.53 | 25.86 |
| | | B′ | 210.17 | 12.93 | 223.10 | 22 57 | 1.53 | 24.10 |
| | $CaCN_2$ | C | 165.79 | 14.40 | 180.19 | 19.07 | 1.60 | 20.67 |
| | | D | 159.89 | 14.07 | 173.96 | 18.13 | 1.77 | 19.90 |
| Sandy soil | $(NH_4)_2SO_4$ | A | 186.60 | 13.38 | 199.98 | 17.80 | 1.30 | 19.10 |
| | | A′ | 176.44 | 10.59 | 186.94 | 17.90 | 0.98 | 18.88 |
| | | B | 189.65 | 12.83 | 202.48 | 18.75 | 1.25 | 20.00[1] |
| | | B′ | 178.66 | 12.23 | 190.89 | 18.65 | 1.25 | 19.90 |
| | $CaCN_2$ | C | 113.25 | 13.50 | 126.75 | 12.37 | 1.37 | 13.74 |
| | | D | 113.71 | 10.90 | 124.61 | 12.35 | 1.10 | 13.45 |

1). With sandy soil the maximum harvest was obtained from the pots B. In the pots B, the average weight of one plant was 2.5 g. (20/8=2.5) and average yield from one kilo. soil amounted to 1.27 g. (20/15.75=1,27), while one plant of the corresponding pots in the preceding experiment with a large supply of nitrogen amounted to 3.1 g. (21.6/7=3.1) and one kilo. soil produced 1.51 g. (21.6/14.27=1.51).

If we now assume the total yield (in the air-dry state) of the pots D in each case of soil respectively to be = 100, we obtain the following ratio :

| Soil. | N-manure. | Group. | Comparative yield. |
|---|---|---|---|
| Loamy soil | $(NH_4)_2SO_4$ | A | 123 |
| | | A′ | 120 |
| | | B | 130 |
| | | B′ | 121 |
| | $CaCN_2$ | C | 104 |
| | | D | 100 |
| Sand soil | $(NH_4)_2SO_4$ | A | 142 |
| | | A′ | 140 |
| | | B | 149 |
| | | B′ | 148 |
| | $CaCN_2$ | C | 102 |
| | | D | 100 |

The manurial effect of lime-nitrogen, was in this case, with a small dose of nitrogen, far smaller than that of ammonium sulphate. This difference of the manurial effects between lime-nitrogen and ammonium sulphate was further much larger in the case of sandy soil than in the case of loamy soil. In the case of loamy soil, if we assume the comparative yield from the group B (130) to be = 100, and compare the respective yield from the group C (104), we obtain the following ratio :

| Ammonium sulphate. | Lime-nitrogen. |
|---|---|
| 100 | 80 |

The comparative yields in the case of sandy soil would be :

| Ammonium sulphate. | Lime-nitrogen. |
|---|---|
| 100 | 69 |

## IV. General Conclusion.

1). The manurial effect of lime-nitrogen varies greatly with the reaction of the other manuring compounds: it acts best when the total reaction in the soil approaches neutrality.

2). The manurial effect of ammonium sulphate varies also greatly with the reaction of the other manuring compounds: it acts better when sodium phosphate than when superphosphate is applied along with it. Also from this fact, it must be inferred that ammonium sulphate acts best when the reaction of the total manure approaches neutrality.

3). The manurial effect of lime-nitrogen is under favorable conditions equal (see barley experiment) to that of ammonium sulphate; but when the nitrogenous manures are compared in small applications, ammonium sulphate proved superior. This result may be due to the changed state of the reaction.

4). On sandy soil, the action of lime-nitrogen was farther below that of ammonium sulphate than on loamy soil.

## EXPLANATION OF PLATE XXIV.

Fig. 1.

$A_3$ Manured with 8.752 g. ammonium sulphate, 4.6 g. double superphosphate, 3.91 g. potassium sulphate, 8.44 g. sodium sulphate, and 17.27 g. gypsum.

$A'_2$ Manured like $A_3$, but gypsum was here substituted by 10.03 g. limestone meal.

$B_3$ Manured with 8.752 g ammonium sulphate, 9.38 g. secondary sodium phosphate, 3.91 g. potassium sulphate and 17.27 g. gypsum.

$B'_2$ Manured like $B_3$, but gypsum was here replaced by 10.03 g. limestone meal.

$C_1$ Manured with 10 g. lime-nitrogen, 4.6 g. double superphosphate, 3.91 g. potassium sulphate and 8.44 g. sodium sulphate.

$D_3$ Manured with 10 g. lime-nitrogen, 9.38 g. secondary sodium phosphate and 3.91 g. potassium sulphate.

Fig. 2

$A_1$ Manured with 12 g. ammonium sulphate, 2.2 g. double superphosphate, 5.2 g. potassium sulphate, 4.05 g. sodium sulphate, and 23.03 g. gypsum.

$A'_2$ Manured like $A_1$, but gypsum was here replaced by 13.38 g. limestone meal.

$B_1$ Manured with 12 g. ammonium sulphate, 4.5 g. secondary sodium phosphate, 5.2 g. potassium sulphate, and 23.03 g. gypsum.

$B'_3$ Manured like $B_1$, but gypsum was here substituted by 13.38 g. limestone meal.

$C_2$ Manured with 13.34 g. lime-nitrogen, 2.2 g. double superphosphate, 5.2 g. potassium sulphate and 4.05 g. sodium sulphate.

$D_1$ Manured with 13.34 g. lime-nitrogen, 4.5 g. secondary sodium phosphate and 5.2 g. potassium sulphate.

(1)

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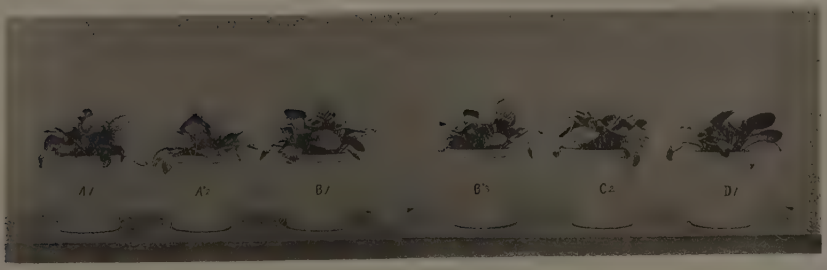
(2)

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# Some Observations on Manuring with Bone-dust.

BY

S. UCHIYAMA.

The observation of Kellner and Böttcher that the availability of bone dust, but not that of secondary calcium phosphate,[1] Thomas phosphate and superphosphate is depressed by calcium carbonate has been repeatedly confirmed and was explained by the neutralization of the soil acidity by liming.[2] In order to gain some further information the action of bone dust in the presence of gypsum and of magnesium sulphate respectively was compared with the depressions caused by the presence of the carbonates of lime, magnesia and potassa with both sand and soil cultures.

*Sand-culture :* The experiment was carried out with of barley in six series, each in three pots. Each pot contained 6 kilo. pure quartz sand, and received the following manures[3] :

15.64 g. bone dust.
3.86 g. ammonium nitrate (In Series F substituted by $NaNO_3$)
2.7 g. potassium sulphate ( „ „ „ partly besides $K_2CO_3$)
0.5 g. ferric hydrate.

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1). It might therefore be supposed that carbonic acid of the soil-air suffices to render this phosphate available to the roots, while for bone dust a more powerful acid seems to be necessary to render it thoroughly available.

2). Also the acidity of the rootlets doubtless plays a part.

3). The bone dust (steamed and partly deprived of glue) was of extreme fineness, $<0.5$ m.m. and contained 1.39 % N, 29.58 % $P_2O_5$, 37.88 % CaO and 1.27 % MgO.
The magnesit contained 47.05 % MgO.
The other manuring compounds were chemically pure.

Series A, received so much magnesia in the form of 8 g. powdered magnesit (<0.5 m.m.) that the ratio $\frac{CaO}{mg}$ was $= \frac{1}{1}$. The bone dust was here the only source of lime.

Series B, contained the magnesia in the form of 0.78 g. crystallized sulphate which dose will be about agronomically equivalent in sand to 8 g. magnesit.

Series C, contained 3.42 g. lime-stone meal, every other particular = A; hereby the ratio $\frac{CaO}{MgO} = \frac{1.5}{1}$ resulted.

Series D, contained 6.84 g. limestone meal, every particular = A; hereby the ratio $\frac{CaO}{MgO} = \frac{2}{1}$ was produced.

Series E, like A, but 11.76 g. gypsum were added, yielding thus the ratio $\frac{CaO}{MgO} = \frac{2}{1}$; but one half of the lime is here more easily available than the other half.

Series F, like A, but a certain portion of potassium sulphate was replaced by 0.4 g. $K_2CO_3$. Ammonium nitrate had here to be replaced by an equivalent amount of *sodium nitrate*[1] in order to avoid the formation of the injurious ammonium carbonate.

The following table will show the quantitative data in regard to manuring conveniently:

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1). Seelhorst as well as Prianishnikow and Söderbaum have already observed that in the presence of sodium nitrate the phosphoric acid of rock and bone phosphate is not so easily available as in the presence of ammonium sulphate or ammonium nitrate. In the former case, sodium carbonate was believed to be gradually formed.

| Manure. | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Bone dust ... ... ... | 15.64 g. | ditto. | ditto. | ditto. | ditto. | ditto. |
| Ammonium nitrate ... | 3.86 g. | ditto. | ditto. | ditto. | ditto. | — |
| Sodium nitrate ... ... | — | — | — | — | — | 8.19 g. |
| Potassium sulphate ... | 2.7 g. | ditto. | ditto. | ditto. | ditto. | 2.2 g. |
| Potassium carbonate ... | — | — | — | — | — | 0.4 g. |
| Ferric hydrate ... ... | 0.5 g. | ditto. | ditto. | ditto. | ditto. | ditto. |
| Magnesit ... ... ... | 8 g. | — | 8 g. | ditto. | ditto. | ditto. |
| Magnesium sulphate ... | — | 0.78 g. | — | — | — | — |
| Limestone ... ... ... | — | — | 3.42 g. | 6.84 g. | — | — |
| Gypsum ... ... ... | — | — | — | — | 11.76 g. | — |
| Ratio $\frac{CaO}{MgO}$ ... ... ... | $\frac{1}{1}$ | $\frac{1}{\left(\frac{1}{30}\right)}$ | $\frac{1.5}{1}$ | $\frac{2}{1}$ | $\frac{2}{1}$ | $\frac{1}{1}$ |

On Nov. 4, 1904, bone dust, magnesit, limestone, gypsum, and ferric hydrate,[1] were applied to the respective pots; and a part of the soluble nutrients the next day in solution, the rest Feb. 20.

On December 12, the young plants of sixsided barley of about 6 cm. were transplanted, each pot receiving three bundles, each consisting of three plants. During vegetation, the plants of the pots B and E showed a most luxuriant development and a *deep green color*, while those of the other pots showed a poor growth and a somewhat pale color; the poorest of all were the plants in E. The following table shows the height of plants, and numbers of stems and ears:

1). The ferric hydrate was freshly precipitated and applied in suspension.

Average of three parallel pots.

| | January 17. | | May 24. | |
|---|---|---|---|---|
| | Height (cm.). | No. of stems. | Height (cm.). | No. of ears. |
| A | 16.7 | 24 | 85.5 | 18 |
| B | 16.4 | 25 | 79.1 | 18 |
| C | 16.1 | 24 | 87.9 | 14 |
| D | 17.0 | 25 | 76.1 | 11 |
| E | 17.9 | 24 | 80.6 | 19 |
| F | 16.1 | 25 | 60.6 | 7 |

The adjoining Plate XXV, Fig. 1 (photogr. May 12) shows the difference in development. The ears appeared gradually, about two weeks passing between the earliest and latest sproutings; the differences will be seen from the following table:

Average of three parallel pots.

| | Ears appeared. |
|---|---|
| A | May 1 |
| B | April 26 |
| C | May 4 |
| D | „ 8 |
| E | April 24 |
| F | May 9 |

The plants were harvested June 10, and weighed in the air-dry state with the following result, g.:

Average of three parallel pots.

| | Grains. | Straw. | Chaffs. | Roots. | Total. |
|---|---|---|---|---|---|
| A | 17.95 | 26.60 | 3.30 | 4.30 | 52.15 |
| B | 17.00 | 30.20 | 2.00 | 5.13 | 54.33 |
| C | 17.27 | 23.57 | 1.50 | 4.07 | 46.41 |
| D | 11.83 | 17.57 | 1.17 | 4.07 | 34.64 |
| E | 22.10 | 31.45 | 2.60 | 6.75 | 62.90 |
| F | 6.90 | 8.80 | 0.60 | 1.80 | 18.10 |

If we now assume the total yield of the pots B to be=100, we obtain the following ratio:

A ($MgCO_3$) ... ... ... ... ... ... ... ... ... ... ... ... ... 96
B ($MgSO_4$) ... ... ... ... ... ... ... ... ... ... ... ... ... 100
C ($CaCO_3 + MgCO_3$) ... ... ... ... ... ... ... ... ... ... ... 85
D ($CaCO_3 + MgCO_3$) ... ... ... ... ... ... ... ... ... ... ... 64
E ($CaSO_4 + MgCO_3$) ... ... ... ... ... ... ... ... ... ... ... 116
F ($K_2CO_3 + MgCO_3$) ... ... ... ... ... ... ... ... ... ... ... 33

From the observations and this yield, it may be inferred:

1. Magnesit acts like limestone, depressing the availability of bone dust (compare A, C and D with B)[1].
2. The ratio CaO : Mg=2 : 1 (D) depressed the harvest more than the ratio CaO : Mg=1 : 1 (A) which is in full accordance with results obtained also in other cases with cereals.

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1). Recently Koch and Gröber (Fühlings Landw. Zeitg. 1906, p. 225) inferred from their experiments that this depressing effect is also due to the neutralization of the acids produced by bacteria in the soil. But the conditions in the soil are often entirely different from those in flasks. These authors applied solutions of 2–5 % dextrose to bone dust in the absence and in the presence of calcium carbonate, and of course observed that in the absence of calcium carbonate the phosphate was dissolved considerably by the bacterial action. But in the soil, suitable carbohydrates are generally absent, and therefore acid can not be produced. On the contrary, the soil-bacteria produce ammonium carbonate by the rottening process of the organic matter of the bone dust, and in this case the solubility of the tertiary phosphates will certainly be very much smaller than in the former case, i.e. in the presence of glucose.

3. Even a certain excess of gypsum produced the most favorable result. The different availability of calcium carbonate and sulphate[1] partly accounts for the fact that here the ratio $CaO : MgO = 2 : 1$[2] did not depress the harvest.
4. In the presence of sodium nitrate, the phosphoric acid of bone phosphate is not so easily available as in the presence of ammonium sulphate (compare F with the other pots) in accordance with the results of other investigators.
5. In the pot E with 0.4 g. potassium carbonate, the harvest was poorest; but in how far this was due to the substitution of ammonium nitrate by sodium nitrate and in how far to the increased alkaline reaction caused by potassium carbonate, could not directly be decided.
6. Since the plants grown with gypsum were of a deeper green than those grown with carbonates, it seems that the chlorophyll production was also somewhat interfered with in the latter cases. Further, investigations on this point however are contemplated.

The above observations with sand-culture rendered it desirable to compare also in soil-culture the effect of potassium carbonate and also of wood ash with that of potassium sulphate, when bone dust serves as a phosphatic manure.

*Soil-culture :* An alluvial sandy soil poor in humus was selected for this purpose, since the presence of much humus would have led probably to the neutralization of potassium carbonate.

## Experiment with Barley.

The experiment was carried out in two parallel series. Eight zinc pots received 10 kilo. air-dry soil. On Nov. 4, 1904, 6 g. sodium

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1). O. Loew and K. Aso: "On Different Degrees of Availability of Plant Nutrients," The Bulletin, Col. of Agric., Tokyo, Vol. VI., No. 4, p. 335.

2). One plant showed here an average weight of 7 g. in the air-dry state, which is certainly a good result for sand-culture.

nitrate[1] and 2 g. bone dust[2] were applied as general manure to each pot. While 1.61 g potassium carbonate[3] was added to each of the first two pots, each of the second two pots received as much wood ash[4] as corresponded to potassium carbonate so that the potassa content was equal. Each of the third two pots with wood ash received less bone dust than the others, since the wood ash itself contained 3.5 % $P_2O_5$. This amount was calculated as bone dust and subtracted from the 2 g. bone dust applied to the other pots; probably the phosphoric acid in the wood ash is also present chiefly as tertiary calcium phosphate. To make up the difference in nitrogen the amount of sodium nitrate was raised to 6.2 g. In each of the fourth two pots, the potassa was applied as sulphate[5] in doses equivalent to the potassium carbonate, applied to the others. The following table gives the quantitative data in regard to manuring:

| Nutrients. | I | II | III | IV |
|---|---|---|---|---|
| Sodium nitrate ... ... ... ... | 6.0 g. | ditto. | 6.2 g. | 6.0 g. |
| Bone dust ... ... ... ... ... | 2.0 g. | ditto. | 0.8 g. | 2.0 g. |
| Potassium carbonate ... ... ... | 1.61 g. | —— | —— | —— |
| Wood ash ... ... ... ... ... | —— | 9.5 g. | ditto. | —— |
| Potassium sulphate ... ... ... | —— | —— | —— | 1.94 g. |
| Total nitrogen ... ... ... ... | 1.01 g. | ditto. | ditto. | ditto. |
| „ phosphoric acid ... ... ... | 0.56 g. | 0.89 g. | 0.56 g. | ditto. |
| „ potassa... ... ... ... ... | 1.05 g. | ditto. | ditto. | ditto. |

On Nov. 6, twenty seeds of sixsided barley were sown per pot, and after nine days the young shoots came up almost stimultaneously. The

1). Sodium nitrate (16 % N) was intentionally applied as a source of nitrogen, since ammonium sulphate, being physiologically acid, would have interferred with the alkalinity of the manure (potassium carbonate and wood ash), the effect of which was to be observed.

2). The bone dust (steamed and partly deprived of glue) was of extreme fineness, <0.5 m.m., and contained 2.71 % N and 27.73 % $P_2O_5$.

3). The potassium carbonate contained 65 % $K_2O$.

4). The wood ash contained 11 % $K_2O$, and 3.50 % $P_2O_5$.

5). The potassium sulphate contained 54 % $K_2O$.

plants were thinned to 15 per pot on December 7, taking care that they were all equal in size.

During vegetation, the plants showed no very great differences, as will be seen from the following table:

Average of two parallel pots.

| Group. | | I | II | III | IV |
|---|---|---|---|---|---|
| Manures per pot. | | 6 g. $NaNO_3$<br>2 g. bone dust<br>1.61 g. $K_2CO_3$ | 6 g. $NaNO_3$<br>2 g. bone dust<br>9.5 g. wood ash | 6.2 g. $NaNO_3$<br>0.8 g. bone dust<br>9.5 g. wood ash | 6 g. $NaNO_3$<br>2 g. bone dust<br>1.94 g. $K_2SO_4$ |
| Dec. 7 | Height of plants (cm.) | 7.8 | 9.2 | 8.3 | 8.1 |
| | No. of shoots ... ... | 15 | 15 | 15 | 15 |
| Jan. 17 | Height of plants (cm.) | 12.0 | 13.7 | 12.1 | 11.8 |
| | No. of shoots ... ... | 51 | 56 | 15 | 53 |
| Feb. 2 | Height of plants (cm.) | 17.2 | 19.4 | 16.8 | 17.1 |
| | No. of shoots ... ... | 70 | 59 | 60 | 61 |
| March 20 | Height of plants (cm.) | 28.9 | 29.5 | 31.1 | 26.3 |
| | No. of shoots ... ... | 71 | 68 | 68 | 71 |
| April 19 | Height of plants (cm.) | 70.9 | 73.5 | 79.6 | 73.2 |
| | No. of shoots ... ... | 41 | 37 | 33 | 39 |
| May 26 | Height of plants (cm.) | 103.2 | 110.8 | 103.0 | 104.7 |
| | No. of ears ... ... | 34 | 31 | 31 | 33 |

The plants were harvested on June 5, and weighed in the air-dry state with the following result, g.:

Average of two parallel pots.

| Group. | I | II | III | IV |
|---|---|---|---|---|
| Manures per pot. | 6 g. $NaNO_3$<br>2 g. bone dust<br>1.61 g. $K_2CO_3$ | 6 g. $NaNO_3$<br>2 g. bone dust<br>9.5 g. wood ash | 6.2 g. $NaNO_3$<br>0.8 g. bone dust<br>9.5 g. wood ash | 6 g. $NaNO_3$<br>2 g. bone dust<br>1.94 g. $K_2SO_4$ |
| Grains ... ... ... | 49.8 | 54.5 | 50.2 | 52.0 |
| Straw ... ... ... | 51.2 | 52.9 | 49.9 | 47.5 |
| Chaffs ... ... ... | 4.0 | 3.9 | 3.9 | 4.2 |
| Total ... ... ... | 105 0[1] | 111.3 | 104.0 | 103.7[2] |

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio:

| I | II | III | IV |
|---|---|---|---|
| 101 | 107 | 100 | 100 |

Hence there was no decisive difference between the effects of potassium sulphate and potassium carbonate when the nitrogen was added as nitrate.

Experiment with Soy-bean.

Eight zinc pots were manured as follows:

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1). The weight of one plant in the group I would therefore be 7 g. in the air-dry state (105-:-15=7).

2). The average weight of one plant in the group IV was again 7 g. (103.7-:-15=7). In the first experiment, when bone dust was applied together with ammonium nitrate and gypsum, the average weight of one plant was also 7 g. (62.7-:-9=7).

| Nutrients[1]. | I | II | III | IV |
|---|---|---|---|---|
| Sodium nitrate ... ... ... ... | 2.84 g. | ditto. | 3.1 g. | 2.84 g. |
| Bone dust ... ... ... ... ... | 6.0 g. | ditto. | 4 04 g. | 6.0 g. |
| Potassium carbonate ... ... ... | 2.5 g. | — | — | — |
| Wood ash ... ... ... ... ... | — | 15.5 g. | 15.5 g. | — |
| Potassium sulphate ... ... ... | — | — | — | 3.2 g. |
| Total nitrogen ... ... ... ... | 0.61 g. | ditto. | ditto. | ditto. |
| „ phosphoric acid ... ... ... | 1.66 g. | 2.29 g. | 1.66 g. | ditto. |
| „ potassa... ... ... ... ... | 1.70 g. | ditto. | ditto. | ditto. |

Ten seeds of soy-bean previously steaped in water were sown per pot June 6. The young shoots appeared after five days, except in pots IV ($K_2SO_4$), which came up three days later. The plants were reduced later on to six per pot of about equal size. All plants showed nearly equal development, only those of the pots II seemed always somewhat a head[2]. The following table shows the height of the plants on Sept. 21:

Average of two parallel pots.

| Group. | I | II | III | IV |
|---|---|---|---|---|
| Manures per pot. | 2.84 g. $NaNO_3$<br>6 g. bone dust<br>2.5 g. $K_2CO_3$ | 2.84 g. $NaNO_3$<br>6 g. bone dust<br>15.5 g. wood ash | 3.1 g. $NaNO_3$<br>4.04 g. bone dust<br>15.5 g. wood ash | 2.84 g, $NaNO_3$<br>6 g. bone dust<br>3.2 g. $K_2SO_4$ |
| Height (cm.) ... | 54.1 | 57.1 | 52.3 | 54.5 |

The plants were harvested on Sept. 21, and weighed in the air-dry state with the following result, g.:

1). The nutrients were the same as those applied in the former experiment, except the sample of potassium carbonate which was here quite pure.

2). In the pots II the amount of phosphoric acid was larger than in the other pots, since the phosphoric acid of the wood ash was added to the dose of bone dust in I and IV.

Average of two parallel pots.

| Group. | I | II | III | IV |
|---|---|---|---|---|
| Manures per pot. | 2.84 g. $NaNO_3$<br>6 g. bone dust<br>2.5 g. $K_2CO_3$ | 2.84 g. $NaNO_3$<br>6 g. bone dust<br>15.5 g. wood ash | 3.1 g. $NaNO_3$<br>4.04 g. bone dust<br>15.5 g. wood ash | 2.80 g. $NaNO_3$<br>6 g. bone dust<br>3.2 g. $K_2SO_4$ |
| Grains ... ... ... | 52.67 | 53.99 | 49.73 | 50.96 |
| Stalks, husks, roots etc. | 65.35 | 74.79 | 65.03 | 62.35 |
| Total ... ... ... ... | 118.02 | 128.78 | 114.76 | 113.31 |

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio:

| I | II | III | IV |
|---|---|---|---|
| 104 | 114 | 101 | 100 |

This result coincides with that of the former experiment with barley.

## Second Experiment with Barley.

This experiment was carried out in three parallel series, and with a different soil (alluvial sand). In order to examine here the productivity of the original phosphoric acid in the soil, pots without phosphatic manure served for comparison. On October 29, fifteen zinc pots received each 12 kilo. air-dry soil with the following manures[1].

1). Each manure had the following percentage amount of nutrient:

The sodium nitrate = 13.92 % N.

The wood ash = 17.24 % $K_2O$ and 3.14 % $P_2O_5$.

The other manuring compounds were the same as in the former experiment with barley in sand-culture.

| Nutrients. | I | II | III | IV | V |
|---|---|---|---|---|---|
| Sodium nitrate ... ... | 20.25 g. | ditto. | 20.6 g. | 20.25 g. | 21.25 g. |
| Bone dust ... ... ... | 10.0 g. | ditto. | 6.47 g. | 10.0 g. | — |
| Potassium carbonate ... | 8.8 g. | — | — | — | — |
| Wood ash ... ... ... | — | 34.8 g. | ditto. | — | — |
| Potassium sulphate ... | — | — | — | 11.09 g. | ditto. |
| Total nitrogen ... ... | 2.96 g. | ditto. | ditto. | ditto. | ditto. |
| „ phosphoric acid... | 2.96 g. | 4.05 g. | 3.00 g. | 2.96 g. | — |
| „ potassa ... ... | 5.99 g. | ditto. | ditto. | ditto. | ditto. |

On December 15, the young plants of sixsided barley of about 6 cm. were transplanted so that each pot received five bundles, each consisting of three plants. During vegetation, all plants with bone dust (I, II, III, and IV) developed almost equally well, while those without phosphatic manure (V) showed a poor growth, as will be recognized from the following table :

Average of three parallel pots.

| Group. | | I | II | III | IV | V |
|---|---|---|---|---|---|---|
| Manures of pot. | | 20.25 g. $NaNO_3$ 10 g. bone dust 7.8 g. $K_2CO_3$ | 20.25 g. $NaNO_3$ 10 g. bone dust 34.8 g. wood ash | 20.60 g. $NaNO_3$ 6.47 g. bone dust 34.8 g. wood ash | 20.25 g. $NaNO_3$ 10 g. bone dust 11.09 g. $K_2SO_4$ | No phosphatic manure |
| Jan. 17 | Height of plants (cm.) | 14.2 | 13.4 | 13.9 | 14.0 | 14.5 |
| | No. of stems | 35 | 36 | 34 | 36 | 30 |
| May 24 | Height of plants (cm.) | 99 8 | 96.2 | 94.0 | 94.3 | 78.0 |
| | No. of ears | 36 | 36 | 36 | 37 | 21 |

The adjoining plate (photogr. May 24) xxv, Fig. 2 shows the general development.

The plants were harvested June 8, and weighed in the air-dry state with the following result, g. :

Average of three parallel pots.

| Group. | I | II | III | IV | V |
|---|---|---|---|---|---|
| Manures of pot. | 20.25 g. $NaNO_3$<br>10 g. bone dust<br>7.8 g. $K_2CO_3$ | 20.25 g. $NaNO_3$<br>10 g. bone dust<br>34.8 g. wood ash | 20.6 g. $NaNO_3$<br>6.47 g bone dust<br>34.8 g. wood ash | 20.25 g. $NaNO_3$<br>10 g. bone dust<br>11.09 g. $K_2SO_4$ | No phosphatic Manure. |
| Grains ... ... | 43.9 | 39.6 | 44.3 | 48.7 | 21.2 |
| Straw ... ... | 62.2 | 66.5 | 70.1 | 73.7 | 35.0 |
| Chaff ... ... | 7.0 | 6.2 | 7.1 | 7.5 | 4.1 |
| Total ... ... | 113.1⊕ | 112.3 | 121.5 | 129.9⊕ | 60.3 |

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio :

| I | II | III | IV | V |
|---|---|---|---|---|
| 87 | 86 | 94 | 100 | 46 |

From these results, which differ partly from those obtained with plain sand-culture (see above) it may be concluded that the harvests of barley obtained on sandy soils with *bone dust and sodium nitrate as manure do not show great differences when in one case the potassa is supplied as potassium sulphate and in the other as potassium carbonate.* On one soil, the result was nearly equal, while on the second soil, potassium sulphate yielded a somewhat better result. Also the potassa in the form of wood ash yielded a result not behind the other case. *Wood ash and bone dust may therefore be applied together.*

This behavior of potassium carbonate in the soil manured with bone dust required some further chemical examination, for there was a direct action of it on the bone dust possible with gradual formation of potassium phosphate and calcium carbonate.

⊕ The weight of one plant in the group I would therefore be 7 g. in the air-dry state and of the group IV 8 g. In the first experiment when bone dust was applied together with ammonium nitrate and gypsum the average weight of one plant was also 7 g. In the second experiment, the average weights of one plant in the pots I and IV were again 7 g.

In order to decide this question, 25 g. bone dust[1] as well as equivalent doses of bone ash[2] were left with frequent shaking in 2.5 litres of water as well as of 1% potassium carbonate solution for $4\frac{1}{2}$ months[3] at room temperature; in one case 5 c.c. of neutral chloroform were added to prevent any bacterial action, while in the others chloroform was excluded. Phosphoric acid had indeed after that time passed into solution; therefore potassium phosphate must have been formed. The quantitative determinations in one litre of the liquid gave the following results:

| | | Milligr. $P_2O_5$ dissolved in one litre. | | |
|---|---|---|---|---|
| | | After 1 month. | After 2 months | After $4\frac{1}{2}$ months. |
| I | Bone dust in water ... ... ... ... ... | 7.65 | —— | 12.66 |
| II | Bone ash „ „ ... ... ... ... ... | 0.57 | —— | 0.71 |
| III | Bone dust in water with chloroform... ... | 5.29 | —— | 7.46 |
| IV | Bone ash „ „ „ „ ... ... | 0.19 | 0.51 | 0.64 |
| V | Bone dust in 1% $K_2CO_3$ solution ... ... | 45.91 | 47.82 | 68.95 |
| VI | Bone ash „ „ „ „ ... ... | 8.16 | 8.99 | —— |
| VII | Bone dust in 1% $K_2CO_3$ solution with chloroform | 44.51 | 45.78 | 56.04 |
| VIII | Bone ash „ „ „ „ „ „ | 5.42 | 6.89[4] | 8.42 |

These numbers show that *the bacteria play indeed a role causing solution of phosphoric acid from bone dust* (compare I with III). In the presence of bacteria (I), the amount of dissolved phosphoric acid had increased by 70%[5] after $4\frac{1}{2}$ months over the amount of dissolved phosphoric acid in the presence of chloroform.

When we further compare II and IV, we find that the absence of chloroform has not led to any notable increase of the dissolved phosphoric

1). The bone dust was the same as that applied in the above fourth experiment.

2). The bone ash was freshly prepared by igniting 25 g. bone dust mentioned.

3). From December 26, 1905 to May 11, 1906.

4). This figure is smaller than the corresponding figure of VI (8.99), which may be due to the gradual decomposition of chloroform by the potassium carbonate, whereby potassium chloride and potassium formate result.

5). 7.46 : 12.66 = 100 : 170.

acid. This different behavior from bone dust is very easily explained by the absence of organic matter in bone ash, excluding therefore the possibility of bacterial growth.

Further more, it becomes evident that potassium carbonate has acted chemically on the bone dust with the formation of potassium phosphate, as becomes clear in comparing V and VII. The presence of chloroform in this case, depressed the dissolution of phosphoric acid comparatively little, proving that *the chemical influence of potassium carbonate on bone dust was much more powerful, than the effect of the bacterial action.*

Further it becomes clear that the potassium carbonate acts with much more difficulty on bone ash than on bone dust (Compare IV and VIII with V and VII).

As a general result, however, it follows that the depressing effect which potassium carbonate would no doubt exert on account of its alkalinity on the availability of bone dust is counterbalanced by its chemical action on bone dust in which gradually potassium phosphate and calcium carbonate are produced.

## EXPLANATION OF PLATE XXV.

Fig. 1.

$A_{III}$ Manured with 15.64 g. bone dust, 3.86 g. ammonium nitrate, 2.7 g. potassium sulphate, 0.5 g. ferric hydroxide, and 8 g. magnesit.

$B_{II}$ Manured like $A_{III}$, but magnesit was here substituted by 0.78 g. crystallized magnesium sulphate.

$C_{III}$ Manured like $A_{III}$ with an addition of 3.42 g. limestone meal.

$D_{III}$ Manured like $C_{III}$, but the amount of limestone was here increased to 6.84 g.

$E_{III}$ Manured like $D_{III}$, but limestone was here replaced by the equivalent amount of gypsum (11.76 g.).

$F_{II}$ Manured with 15.64 g. bone dust, 8.19 g. sodium nitrate, 2.2 g. potassium sulphate, 0.4 g. potassium carbonate, 0.5 g. ferric hydroxide and 8 g. magnesit.

Fig. 2.

$I_3$ Manured with 20.25 g. sodium nitrate, 10 g. bone dust, and 7.8 g. potassium carbonate.

$II_1$ Manured with 20.25 g. sodium nitrate, 10 g. bondust, and 34.8 g. wood ash.

$III_3$ Manured with 20.6 g. sodium nitrate, 6.47 g. bone dust, and 34.8 g. wood ash.

$IV_3$ Manured with 20.25 g. sodium nitrate, 10 g. bone dust, and 11.09 g. potassium sulphate.

$V_3$ Received no phosphatic manure.

(1)

To Page 108.

(2)

To Page 116.

# On the Cultivation of Astragalus Lotoides.

BY

**T. IMASEKI.**

In many districts of Japan, the farmers practice since olden times sowing the seeds of a leguminous plant called '*Genge*,' *Astragalus lotoides*, in September or October, between the rice-plants in paddy fields. This plant attains in the following spring the flowering stage before the new rice is transplanted, and it is then incorporated in the field as green manure.

This practice, which obviously causes an accumulation of nitrogen in the soil, is extending more and more throughout the rice-growing districts of Japan. But, as the accumulation of nitrogen by the Genge-plant is accomplished by the symbiotic growth with its root bacteria, an inoculation of these bacteria should be carried on in such districts, where the cultivation of Genge has not been practised before.

In order to study the best modes of inoculation, I have made a preliminary experiment. Sixteen zinc cylinders, of 2500 sq. cm. surface were filled with the soil from an unmanured field of this Experiment Station. The plan of the experiment was as follows :—

| | | Manure. | | |
|---|---|---|---|---|
| | | Per cylinder. | | per hectare. |
| | | Sodium phosphate, g | Potassium carbonate, g | |
| I. No manure | a. original seed | — | — | — |
| | b. inoculated seed | — | — | — |
| II. Phosphoric acid and potash | a. original seed | 18.5 | 5.6 | 150 kilo. $P_2O_5$<br>150 „ $K_2O$ |
| | b. inoculated seed | 18,5 | 5.6 | „ „ „<br>„ „ „ |

Sodium phosphate and potassium carbonate were applied in solution September 23, and well mixed with the soil.

The seeds of *Genge* were at first steeped for about 24 hours in water or in the water containing nodule bacteria, which had been prepared in pure culture. The seeds were sown September 26. Each case was carried out in four series.

In winter, chopped straw was spread over all the cylinders for protection.

In spring, it became noticeable that the plants developed from inoculated seeds were of a fresher green color than those grown from the check seeds.

On May 8, the plants were cut and also the roots were isolated from the soil. The inoculated plants showed numerous nodules at the upper parts of the roots, while the check plants had comparatively few nodules.

The results were as follows (average of 4 cylinders):—

| No. of cylinders. | | In the fresh state. | | | In the air-dry state. | | | Comparative yield. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Stems & leaves g | Roots g | Whole plant g | Stems & leaves g | Roots g | Whole plant g | Stems & leaves. | Whole plant. |
| I. No manure | a. original seed | 1915. | 267.9 | 2182.9 | 265.3 | 35.58 | 300.88 | 100 | 100 |
| | b. inoculated seed | 2089. | 287.1 | 2376.1 | 302.0 | 41.46 | 343.46 | 114 | **114** |
| II. Phosphoric acid and potash | a. original seed | 2029. | 299.5 | 2328.5 | 277.5 | 37.63 | 315.13 | 105 | 105 |
| | b. inoculated seed | 2316. | 292.3 | 2608.3 | 326.3 | 39.68 | 365.98 | 123 | **122** |

From the above figures we can decidedly conclude that the inoculated seeds invariably gave better results than the original seeds.

Moreover, as in Japan *Genge* is one of the most important green manures, it is of some interest to know the comparative yield in stems, leaves, and roots of this plant, hence I have carefully determined the respective harvests.

I. Air-dry matter of fresh leaves and stems:

| | |
|---|---|
| Maximum | 15.76 % |
| Minimum | 12.80 „ |
| Average of 16 cylinders | 14.14 „ |

II. Air-dry matter of fresh roots:

| | |
|---|---|
| Maximum | 16.95 % |
| Minimum | 10.89 „ |
| Average of 16 cylinders | 13.87 „ |

III. Ratio of Roots to the stems and leaves (in the air-dry state):

| | |
|---|---|
| Maximum | 15.37 % |
| Minimum | 11.53 „ |
| Average of 16 cylinders | 13.22 „ |

IV. Percentage of root in the entire plant:

| | |
|---|---|
| Maximum | 17.00 % |
| Minimum | 10.30 „ |
| Average | 12.32 „ |

V. Proportion of the stems and the leaves in the total yield (excluding the roots):

| | Stems. | Leaves. |
|---|---|---|
| Maximum | 45.61 % | 61.70 % |
| Minimum | 38.30 „ | 54 39 „ |
| Average | 41.87 „ | 58.13 „ |

Also, the nitrogen content of the stems, the leaves, and the roots were determined.

| In the air-dry state. | N |
|---|---|
| Stems | 1.862 % |
| Leaves | 3.543 „ |
| Roots | 2.714 „ |

As to the manurial value of this plant, further studies are intended.

# On the Yield of Polygonum Tinctorium under Different Conditions.

BY

T. IMASEKI.

Since the indigo production from *Polygonum tinctorium* is of some importance in Japan, studies as to the yield of this plant under different manuring conditions seemed desirable. For this purpose, cultures in two different soils were made, their ratios of lime to magnesia were altered and the effect of calcium carbonate was compared with that of gypsum and air-slaked lime.

Soil A was a loamy humus soil derived from an un-manured field of our experimental farm. It contained in 100 parts of the fine-earth 1.08 % CaO and 0.78 % MgO soluble in concentrated hydrochloric acid. As the fine-earth amounted to 82.50% of the original soil, the latter contained 0.891% CaO and 0.619% MgO in an available form and the particles were of sufficiently small size.

Soil B was an alluvial sandy loam from Arakawa near Tokyo, containing in 100 parts of the air-dry fine-earth 0.925% CaO and 1.230% MgO, and as the fine-earth amounted to 82.52% of the original soil, the figures become 0.763% CaO and 1.015% MgO. Sixty pots served for this experiment. These pots held 7.5 kilo. of the soil A and 10.5 kilo. of the soil B, this difference being due to the former soil being much lighter than the latter.

In order to reach the intended ratios of CaO to MgO, the following additions were necessary :—

| No. of pots. | Soil A. | | Soil P. | |
|---|---|---|---|---|
| | Kind of special manures. | CaO : MgO | Kind of special manures. | CaO : MgO |
| I. | Original soil ... ... ... ... | 1.44 : 1 | Original soil ... ... ... .. | 0.75 : 1 |
| II. | „ „ +43.1 gr. magnesite ... | 1 : 1 | „ „ +50.6 gr. limestone ... | 1 : 1 |
| III. | „ „ +50.1 gr. limestone ... | 2 : 1 | „ „ +254.5 gr. „ ... | 2 : 1 |
| IV. | „ „ +139.1 gr. „ ... | 3 : 1 | „ „ +458,4 gr. „ ... | 3 : 1 |
| V. | „ „ +225.5 gr. gypsum ... | 3 : 1 | „ „ +743.3 gr. gypsum ... | 3 : 1 |
| VI. | „ „ +127.5 gr. precipitated $CaCO_3$ | 3 : 1 | „ „ +420.4 gr. precipitated $CaCO_3$ | 3 : 1 |
| VII. | „ „ +151.2 gr. air-slaked lime | 3 : 1 | „ „ +392.8 gr. air-slaked lime | 3 : 1 |
| VIII. | „ „ +75.6 gr. „ „ „ | 2.2 : 1 | „ „ +196.4 gr. „ „ „ | 1.88 : 1 |
| IX. | „ „ +37.8 gr. „ „ „ | 1.9 : 1 | „ „ +98.2 gr. „ „ „ | 1.31 : 1 |
| X. | „ „ +18.9 gr. „ „ „ | 1.6 : 1 | „ „ +49.1 gr. „ „ „ | 1.03 : 1 |

The general manure applied in the beginning of May was as follows :—

| | Per pot. |
|---|---|
| Chili saltpeter[1] ... ... ... ... ... ... ... ... ... ... | 12 grams. |
| Monopotassium phosphate ... ... ... ... ... ... ... ... | 7.5 „ |
| Potassium sulphate ... ... ... ... ... ... ... ... ... ... | 7.5 „ |

The seeds were sown May 5, and the leaves harvested July 9. After harvesting the first crop, each pot was freshly manured with 2 grams of sodium nitrate. The second crop was harvested August 3.

The amounts of the first and the second harvests are shown in the following tables (average of 3 pots) :—

2). One half of the dose was applied later, June 5.

## Soil A.

| No. of pots. | Kind of special manures. | CaO/MgO | First crop (air-dry) g. | | Second crop (air-dry) g. | | Sum of the first and the second crops, g. | | Comparative total yield of leaves. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Leaves. | Stems. | Leaves. | Stems. | Leaves. | Stems. | |
| I | Original soil | 1.44/1 | 5.83 | 2.63 | 5.24 | 5.89 | 11.07 | 8.52 | 100 |
| II | Magnesite... | 1/1 | 8.33 | 3.73 | 5.99 | 7.46 | 14.32 | 11.19 | 129 |
| III | limestone ... | 2/1 | 7.80 | 3.32 | 5.66 | 5.99 | 13.46 | 9.31 | 122 |
| IV | „ ... | 3/1 | 6.79 | 3.43 | 5.77 | 5.54 | 12.56 | 8.97 | 114 |
| V | Gypsum ... | 3/1 | 8.19 | 3.83 | 7 03 | 7.94 | 15.22 | 11.77 | 137 |
| VI | precipitated $CaCO_3$ | 3/1 | 6.74 | 2.98 | 5.90 | 6.28 | 12.64 | 9.26 | 114 |
| VII | air-slaked lime | 3/1 | 6.42 | 2.87 | 6.24 | 7.11 | 12.66 | 9.98 | 114 |
| VIII | „ „ | 2.2/1 | 8.05 | 3.99 | 6.52 | 7.46 | 14.57 | 11.45 | 132 |
| IX | „ „ | 1.9/1 | 8.69 | 3.81 | 6.47 | 7.30 | 15.16 | 11.11 | 137 |
| X | „ „ | 1.6/1 | 9.06 | 4.92 | 6.48 | 7.26 | 15.54 | 12.18 | 140 |

## Soil B.

| No. of pots. | Kind of special manures. | CaO/MgO | First crop (air-dry) g. | | Second crop (air-dry) g. | | Sum of the first and the second crops, g. | | Comparative total yield of leaves. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Leaves. | Stems. | Leaves. | Stems. | Leaves. | Stems. | |
| I | Original soil | 0.75/1 | 6.07 | 3.55 | 4.67 | 5.29 | 10.74 | 8.84 | 100 |
| II | limestone ... | 1/1 | 8.05 | 3.80 | 5.80 | 6.14 | 13.85 | 9.94 | 129 |
| III | „ ... | 2/1 | 7.48 | 3.18 | 6.48 | 6.17 | 13.96 | 9.35 | 130 |

| No. of pots. | Kind of special manures. | CaO/MgO | First crop (air-dry) g. | | Second crop (air-dry) g. | | Sum of the first and the second crops, g. | | Comparative total yield of leaves. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Leaves. | Stems. | Leaves. | Stems. | Leaves. | Stems. | |
| IV | limestone ... | 3/1 | 6.86 | 3.00 | 4.78 | 5.82 | 11.64 | 8.82 | 108 |
| V | gypsum ... | 3/1 | 8.07 | 3.57 | 5.92 | 5.67 | 13.99 | 9.24 | 130 |
| VI | precipitated $CaCO_3$ | 3/1 | 5.48 | 1.97 | 5.03 | 5.01 | 10.51 | 6.98 | 99 |
| VII | air-slaked lime | 3/1 | 5.62 | 2.31 | 5.03 | 6.08 | 10.65 | 8.39 | 98 |
| VIII | „ „ | 1.88/1 | 6.93 | 2.61 | 6.03 | 6.39 | 12.96 | 9.00 | 121 |
| IX | „ „ | 1.31/1 | 7.65 | 2.65 | 6.48 | 7.10 | 14.13 | 9.75 | 132 |
| X | „ „ | 1.03/1 | 7.72 | 3.23 | 5.92 | 6.46 | 13.64 | 9.69 | 127 |

On glancing over the above tables, it will be noticed that *the ratio of lime to magnesia* in the soil has a considerable influence on the yield of *Polygonum tinctorium, the ratios* 1 : 1 *and* 2 : 1 *giving better results than* 3 : 1, *when lime is applied as carbonate or air-slaked lime*[1].

1). With gypsum, however, also the ratio 3 : 1 yielded good results, since the availability of it does not depend on the acidity of the rootlets, but only on its small solubility in water. Hence, an increase of lime in the form of gypsum will not lead to an increased absorption by the roots. Cf. O. Loew and K. Aso, Bul. Coll. of Agri., Tokyo, Vol. VI., No. 4.

# On the Most Favorable Ratio of Lime to Magnesia for the Mulberry Tree.

BY

M. NAKAMURA.

It has been shown by various experiments carried out at the College of Agriculture of the Tokyo Imperial University that a maximum harvest depends, other things being equal, upon a certain ratio of the amount of lime to magnesia available to the roots.

When both these bases are present in an equal degree of availability the most favorable ratio for cereals is $\frac{CaO = 1 \text{ to } 1.5}{MgO = 1}$, while plants with more abundant foliage require 2–4 times more lime than magnesia. Since the mulberry tree is one of the most important agricultural plants in Japan, the export of silk from here reaching a very high figure, it is of considerable value to determine the most favorable ratio of lime to magnesia for that plant. For the experiment served the sub-soil of Nishigahara which contains, according to a former determination, 0.24% CaO and 1.96% MgO soluble in hot hydrochloric acid. Ten zinc pots received 20 kilo. of soil each, while four other pots 60 kilo. each. This soil was sifted before use through a 3 mm. sieve. The general manure consisted, for each 10 kilo. of soil, of 10 g $NaNO_3$, 5 g Amm. phosphate and 5 g $KNO_3$. In order to provide the ratios of CaO : MgO to be tested the following additions were necessary —

(A) (3 pots) $\frac{CaO}{MgO} = \frac{0.12}{1}$ nearly.....Original soil

(B) (3 pots) $\frac{CaO}{MgO} = \frac{1}{1}$ 172 g CaO = 307.14 g $CaCO_3$

(C) (3 pots) $\frac{CaO}{MgO} = \frac{2}{1}$ 368 g CaO = 757.14 g $CaCO_3$

} for each 10 kilo. of soil, respectively.

(D) (3 pots) $\frac{CaO}{MgO} = \frac{3}{1}$ 564 g CaO = 1007 g $CaCO_3$
(E) (2 pots) $\frac{CaO}{MgO} = \frac{4}{1}$ 760 g CaO = 1305.7 g $CaCO_3$
} for each 10 kilo. of soil, respectively.

On May 22, 1904, two young plants of the variety called *Roso* about 1 foot long were planted in each pot, and after a short time a selection was made, leaving one in each pot, all being now of nearly equal size. On May 27 the young branches were cut off. On June 7 new buds appeared in the pots (A) and (C) and on the 9th in other pots, while on the 12th young leaves had developed.

June 7.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| No. of buds ... ... | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

June 9.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| No. of buds ... ... | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| No. of leaves... ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

June 12.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| No. of buds ... ... | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| No. of leaves... ... | 1 | 2 | 1 | 2 | 4 | 0 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |

June 20.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| No. of buds ... ... | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| No. of leaves... ... | 5 | 6 | 3 | 4 | 6 | 2 | 6 | 5 | 4 | 4 | 4 | 5 | 5 | 4 |

June 30.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| No. of buds ... ... | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| No. of leaves... ... | 8 | 8 | 6 | 10 | 9 | 6 | 9 | 7 | 6 | 10 | 7 | 11 | 7 | 6 |

July 15.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| Gight of trunk (cm.) | 31.8 | 29.4 | 12.7 | 26.1 | 34.2 | 28.2 | 41.5 | 36.7 | 24.8 | 39.4 | 29.7 | 28.8 | 33.6 | 30.9 |
| The average (cm.) | 24.6 | | | 29.5 | | | 34.3 | | | 32.6 | | | 32.3 | |
| No. of leaves | 12 | 10 | 8 | 12 | 14 | 13 | 12 | 11 | 9 | 13 | 10 | 13 | 12 | 10 |
| The average | 10 | | | 13 | | | 11 | | | 12 | | | 11 | |

August 3.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| Gight of trunk (cm.) | 45.5 | 38.2 | 14.2 | 36.1 | 51.5 | 37.9 | 59.4 | 53.9 | 30 3 | 59.4 | 39.4 | 45.5 | 37.3 | 58.2 |
| The average (cm.) | 32.6 | | | 41.8 | | | 47.9 | | | 48.1 | | | 47.8 | |
| No. of leaves | 19 | 12 | 9 | 14 | 18 | 20 | 23 | 20 | 13 | 21 | 15 | 17 | 15 | 19 |
| The average | 13 | | | 17 | | | 19 | | | 18 | | | 17 | |

September 10.

| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| Hight of trunk (cm.) | 63.6 | 54.5 | 23.6 | 58.2 | 85.8 | 69.7 | 79.7 | 90.0 | 81.2 | 73.6 | 88.5 | 91.5 | 80.9 | 88.8 |
| The average (cm.) | 47.2 | | | 71.2 | | | 83.6 | | | 84.5 | | | 84.9 | |
| No. of leaves | 23 | 19 | 20 | 34 | 35 | 28 | 77 | 33 | 37 | 35 | 56 | 37 | 55 | 29 |
| The average | 21 | | | 32 | | | 49 | | | 43 | | | 42 | |

October 20.

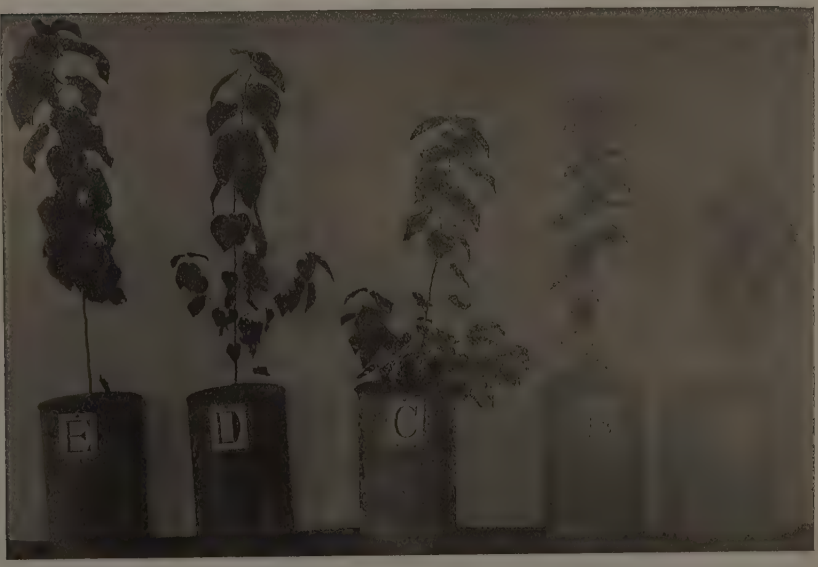
| | A | | | B | | | C | | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | b | c | a | b | c | a | b | c | a | b |
| Hight of trunk (cm.) | 66.4 | 61.2 | 24.2 | 67.3 | 93.9 | 78.8 | 83.3 | 100.3 | 87.9 | 79.4 | 100.5 | 118.2 | 90.9 | 109.1 |
| The average (cm.) | 50.6 | | | 80.0 | | | 90.5 | | | 99.4 | | | 100.0 | |
| No. of leaves | 23 | 22 | 25 | 38 | 53 | 34 | 83 | 38 | 46 | 43 | 66 | 46 | 62 | 35 |
| The average | 23 | | | 41 | | | 55 | | | 51 | | | 48 | |

Photographs were taken, October 25th, which are reproduced on Plate XXVI.

The following table shows the relative development of branches and number of leaves, the production on the original soil being assumed to be 100:

| | Average length. | Average No. of leaves. |
|---|---|---|
| A) Original soil ... ... ... ... | 100 | 100 |
| B) $\frac{CaO}{MgO} = \frac{1}{1}$ ... ... ... ... | 158 | 178 |
| C) „ $= \frac{2}{1}$ ... ... ... ... | 179 | 239 |
| D) „ $= \frac{3}{1}$ ... ... ... ... | 196 | 222 |
| E) „ $= \frac{4}{1}$ ... ... ... ... | 197.6 | 209 |

It will be noticed from the tables just described, that the plants in the pots D and E had the best development in regard to the height of the trunk. Regarding the number of leaves the plants in D were superior to those of E, these containing 3 leaves less. Both these sets of plants were surpassed by the plants in C as to the number of leaves, but in regard to green coloration and size of the leaves the plants D and E were superior to those of C. The result of this experiment, leaves no doubt that for the mulberry tree the best ratio $\frac{CaO}{MgO} = \frac{3}{1}$ i.e. the lime factor for the mulberry tree is $=3$, which agrees very well with a former observation of Prof. Aso.




| E. | D. | C. | B. | A. |
|---|---|---|---|---|
| $\frac{CaO}{MgO} = \frac{4}{1}$ | $\frac{CaO}{MgO} = \frac{3}{1}$ | $\frac{CaO}{MgO} = \frac{2}{1}$ | $\frac{CaO}{MgO} = \frac{1}{1}$ | Original Soil. |

# Are Soils Containing Less than 0.02 % $SO_3$ Benefited by Special Manuring with Sulphates?

BY

G. DAIKUHARA.

Soils containing less than 0.02 % $SO_3$ are rather frequent and since such soils occur in Japan, it has some value to decide whether sulphates would considerably increase the yields by furnishing easily assimilable sulphur for protein formation. I selected for my test three soils which gave the following numbers on analysis[1]:

| | CaO. | MgO. | $P_2O_5$. | $SO_3$. |
|---|---|---|---|---|
| I. | 0.153 % | 0.092 % | 0.025 % | 0.016 % |
| II. | 0.028 „ | 0.118 „ | 0.022 „ | 0.013 „ |
| III. | 0.033 „ | 0.035 „ | 0.017 „ | 0.010 „ |

No. I came from Sakamura in Hiroshima Prefecture and was a sandy loam; No. II came also from Heira-Mura in the same Prefecture and was a clayey soil; and No. III came from Hirono-Mura in Fukushima Prefecture and was also of a clayey nature.

Seventy-two zinc pots containing 13, 14 and 11 Kg soils resp. served for this experiment, three pots for each trial. The general manure per pot for these three soils was:

Sodium nitrate... ... ... ... ... ... ... ... ... 6 g, in two fractions.
Double superphosphate[2]... ... ... ... ... ... ... ... 3 g
Potassium carbonate ... ... ... ... ... ... ... ... 2.5 g

---

1). The analysis was carried out according Ulbricht's method with a hydrochloric acid of 10 %, a little modified by T. Katayama.

2). Only the soluble portion of this preparation served for this experiment and contained 36.76 % $P_2O_5$, 0.81 % CaO and 0.83 % $SO_3$ in the original sample.

In every case also an experiment without general manure was made in order to observe principally the effects of the sulphates added on the condition of the soil, since, especially with clayey and humus soils, the effects on the soils have to be well distinguished from the effects on the plants. Gypsum, magnesium sulphate and sodium sulphate may be able to liberate potassa from hydrous silicates and render it more available to the plants.

With the soil No. I and No. III the lime content was larger than the magnesia content and since barley was to be grown the manuring with magnesia might benefit the barley. In these cases the sulphate was applied in the form of crystallized magnesium sulphate. Further for sake of comparison, magnesia was also applied as magnesite with and without sodium sulphate (equivalent to $MgSO_4$).

In the case of the soil No. II there was more magnesia present than lime, hence the sulphate applied was $CaSO_4.2H_2O$. Control pots contained either limestone or limestone and sodium sulphate. The following table will show the quantities applied per pot:

| Kind of Manures. | Soil No. I. | Soil No. II. | Soil No. III. |
|---|---|---|---|
| $MgSO_4.7H_2O$ ... ... ... | 1.61 g[1] | ——— | 1.30 g[1] |
| Magnesite ... ... ... ... | 16.51 „ | ——— | 13.29 „ |
| $CaSO_4.2H_2O$ ... ... ... | ——— | 9.68 g[2] | ——— |
| $CaCO_3$ ... ... ... ... ... | ——— | 16.88 „[2] | ——— |
| „ ... ... ... ... ... | ——— | 22.50 „[3] | ——— |
| $Na_2SO_4.10H_4O$ ... ... ... | 2.11 g | 18.13 „ | 1.70 g |

Thirty-one seeds p. pot were sown Nov. 29, 1904 and the young plants of about 6 cm. height were reduced to 22, 17 and 21 resp. in the three different soils. The height of plants measured April 8 may be seen in the following table:

1). The MgO plied as sulphate corresponds to 1/30 of the calculated amount of MgO as magnesite.

2). These amounts were applied to the second series of soil No. II pot (2), 1/4 of the calculated amount of CaO being applied as $CaSO_4.2H_2O$ (cf. this Bulletin Vol. I, No. 1, p. 28).

3). This amount was applied to the third series of the soil II.

## Soil No. I.

| Kinds of manure. | A). Without general manure. Height of plants. of each pot. cm. | average. cm. | B). With general manure. Height of plants. of each pot. cm. | average. cm. |
|---|---|---|---|---|
| 1) No special manure ... ... | a. 51.5 | 53.1 | 66.0 | 65.7 |
| | b. 56.5 | | 66.6 | |
| | c. 51.6 | | 64.5 | |
| 2) $MgSO_4.7H_4O$ ... ... ... | a. 49 2 | 51.9 | 69 o | 66.7 |
| | b. 58.5 | | 67.5 | |
| | c. 48 o | | 63.6 | |
| 3) Magnesite ... ... ... ... | a. 53.1 | 52.9 | 63.9 | 66.5 |
| | b. 53.1 | | 68.1 | |
| | c. 52.5 | | 67.5 | |
| 4) Magnesite + $Na_2SO_4$ $10H_2O$. | a. 55.2 | 51.4 | 64.5 | 63.9 |
| | b. 52.5 | | 66.6 | |
| | c. 46.5 | | 60.6 | |

## Soil No. II.

| Kinds of manure. | A). Without general manure. Height of plants. of each pot. cm. | average. cm. | B). With general manure. Height of plants. of each pot. cm. | average. cm. |
|---|---|---|---|---|
| 1) No special manure ... ... | a. 3.9 | 4.4 | 32.1 | 32.5 |
| | b. 4.5 | | 32.4 | |
| | c. 4 8 | | 33.0 | |
| 2) Gypsum + Lime-stone ... | a. 9 6 | 8.6 | 48 o | 48.6 |
| | b. 9.9 | | 51.6 | |
| | c. 6 3 | | 46.2 | |

| Kinds of manure. | A). Without general manure. | | B). With general manure. | |
|---|---|---|---|---|
| | Height of plants. | | Height of plants. | |
| | of each pot. cm. | average. cm. | of each pot. cm. | average. cm. |
| 3) Limestone ... ... ... ... | a. 11.1<br>b. 11.4<br>c. 13.5 | 12.0 | 51.0<br>52.5<br>49.5 | 51.0 |
| 4) Limestone + $Na_2SO_4.10H_2O$. | a. 8.1<br>b. 10.2<br>c. 10.5 | 9.6 | 46.5<br>52.5<br>50.1 | 49 7 |

## Soil No. III.

| Kinds of manure. | A). Without general manure. | | B). With general manure. | |
|---|---|---|---|---|
| | Height of plants. | | Height of plants. | |
| | of each pot. cm. | average. cm. | of each pot. cm. | average. cm. |
| 1) No special manure ... ... | a. 24.9<br>b. 28.8<br>c. 24.6 | 26.1 | 57 6<br>56.1<br>63.0 | 58.9 |
| 2) $MgSO_4.7H_2O$ ... .... ... | a. 24.6<br>b. 22.5<br>c. 24.6 | 23.9 | 62.1<br>57.0<br>—— | 59 6 |
| 3) Magnesite ... ... ... ... | a. 18.6<br>b. 27.9<br>c. 20.7 | 20.4 | 57.0<br>59 4<br>60.0 | 58.8 |
| 4) Magnesite + $Na_2SO_4.10H_2O$ .. | a. 25.5<br>b. 26.1<br>c. 27.9 | 26.5 | 61.8<br>58.5<br>54.6 | 58.3 |

Plants were cut on June 10 and the harvest was weighed in the air-dry state with the following result:

No. I. Hiroshima soil (a).

(A.) Without general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 32 | 93.0 | 28.88 | 50.25 | 3.00 | 82.13 | | |
| | b. | 39 | 97.8 | 25.50 | 59.25 | 2.63 | 87.38 | 26.91 | 85.54 |
| | c. | 33 | 94.5 | 26.36 | 49.13 | 2.63 | 78.12 | | |
| 2) $MgSO_4.7H_2O$.. | a. | 28 | 96.0 | 22.05 | 48.75 | 1.50 | 72.30 | | |
| | b. | 22 | 96.0 | 16.58 | 35.63 | 1.13 | 53.34 | 21.13 | 66.51 |
| | c. | 25 | 88.2 | 24.75 | 46.50 | 2.63 | 73.88 | | |
| 3) Magnesite ... | a. | 26 | 88.2 | 20.25 | 46 88 | 2.63 | 69.76 | | |
| | b. | 29 | 95.1 | 19.13 | 56.25 | 3.00 | 78.38 | 22.13 | 76.38 |
| | c. | 30 | 96 0 | 27.00 | 51.00 | 3.00 | 81.00 | | |
| 4) Magnesite + $Na_2SO_4.10H_2O$ | a. | 33 | 98.4 | 26.63 | 57.00 | 3.38 | 87.01 | | |
| | b. | 29 | 98.1 | 24.75 | 53.25 | 3.38 | 81.38 | 27.63 | 86.51 |
| | c. | 35 | 90.0 | 31.50 | 55.50 | 4.13 | 91.13 | | |

(B.) With general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 61 | 100.8 | 68.25 | 106.88 | 6 75 | 181.88 | | |
| | b. | 61 | 114.0 | 63.38 | 104.25 | 6.38 | 174.01 | 64.75 | 176.13 |
| | c. | 64 | 111.0 | 62.63 | 104.63 | 5.25 | 172.51 | | |
| 2) $MgSO_4.7H_2O$.. | a. | 59 | 106.2 | 69.75 | 114.00 | 6.00 | 189.75 | | |
| | b. | 59 | 112.5 | 60.75 | 106.50 | 5.25 | 172.50 | 66.63 | 181.00 |
| | c. | 61 | 101.4 | 69.38 | 105.38 | 6.00 | 180.76 | | |

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 3) Magnesite ... | a. | 63 | 101.7 | 69.00 | 111.38 | 6.75 | 187.13 | | |
| | b. | 60 | 105.6 | 68.25 | 111.00 | 7.13 | 186.38 | 69.13 | 187.13 |
| | c. | 64 | 108.1 | 70.13 | 111.38 | 6.38 | 187.89 | | |
| 4) Magnesite + $Na_2SO_4.10H_2O$ | a. | 66 | 109.5 | 59.25 | 100.13 | 5 63 | 165.01 | | |
| | b. | 60 | 100.4 | 69 38 | 107.25 | 6.38 | 183.01 | 63 88 | 173.51 |
| | c. | 58 | 107.1 | 63.00 | 103.50 | 6.00 | 172.50 | | |

## No. II. Hiroshima soil (b).

### (A). Without general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 13 | 14.4 | 0 | 0.38 | 0 | 0.38 | | |
| | b. | 15 | 17.1 | 0 | 0 75 | 0 | 0 75 | 0 | 2.00 |
| | c. | 16 | 17.4 | 0 | 4.88 | 0 | 4.88 | | |
| 2) Gypsum + Limestone | 1) a. | — | — | — | — | — | — | | |
| | b. | 18 | 27 3 | 0.15 | 3.00 | 0.05 | 3.20 | 0.27 | 4.51 |
| | c. | 18 | 26.4 | 0.38 | 2.63 | 0.18 | 5.81 | | |
| 3) Limestone ... | a. | 22 | 26.0 | 1.13 | 5.25 | 0.38 | 6.76 | | |
| | b. | 21 | 33.3 | 1.13 | 4.88 | 0.38 | 6.39 | 1.13 | 6.64 |
| | c. | 19 | 36.2 | 1.13 | 5.25 | 0.38 | 6.76 | | |
| 4) Limestone + $Na_2SO_4.10H_2O$ | a. | 14 | 32.1 | 0.38 | 4.13 | 0.18 | 4 69 | | |
| | b. | 16 | 31.5 | 0.75 | 4.88 | 0.38 | 6.01 | 0.50 | 4.75 |
| | c. | 14 | 29.1 | 0.38 | 3.00 | 0.18 | 3.56 | | |

1). Plants in this pot were attacked by fungus.

(B). With general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 29 | 57.9 | 1.13 | 31.88 | 0.75 | 33.76 | 1.25 | 35.13 |
| | b. | 30 | 79.5 | 1 88 | 35.25 | 0.75 | 37.88 | | |
| | c. | 32 | 60.6 | 0.75 | 32.63 | 0.38 | 33.76 | | |
| 2) Gypsum + Limestone | a. | 47 | 87.9 | 32.25 | 66.75 | 3.38 | 102.38 | 34.63 | 104.01 |
| | b. | 46 | 91.8 | 35.25 | 64.50 | 4.13 | 103.88 | | |
| | c. | 42 | 87.0 | 36.38 | 64.50 | 4.88 | 105.76 | | |
| 3) Limestone[1] ... | a. | 44 | 90.0 | 35.25 | 69.38 | 3.38 | 108.01 | 38.63 | 112.51 |
| | b. | 45 | 99.0 | 36.75 | 67 50 | 4.50 | 108.75 | | |
| | c. | 46 | 94.2 | 43.88 | 70.88 | 6.00 | 120 76 | | |
| 4) Limestone + $Na_2SO_4.10H_2O$ | a. | 44 | 93.0 | 31.50 | 62.25 | 4.13 | 97.88 | 41.63 | 116.38 |
| | b. | 55 | 94.5 | 48.75 | 76.50 | 5.25 | 130.50 | | |
| | c. | 49 | 90.0 | 44.63 | 71.25 | 4.88 | 120.76 | | |

No. III. Fukushima soil.

(A). Without general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 22 | 57.0 | 10.13 | 14.63 | 1.50 | 26.26 | 10.00 | 26.38 |
| | b. | 21 | 59.4 | 10.13 | 15.75 | 1.50 | 27.38 | | |
| | c. | 21 | 62.1 | 9.75 | 14.25 | 1.50 | 25.50 | | |
| 2) $MgSO_4.7H_2O$.. | a. | 21 | 56.4 | 7.88 | 13.88 | 1.13 | 22.89 | 7.75 | 24.26 |
| | b. | 22 | 57.9 | 8.63 | 15.38 | 1.50 | 25.51 | | |
| | c. | 24 | 46.5 | 6.75 | 16.13 | 1.50 | 24.38 | | |

1). A part of this increase by limestone may be due to the improvement of the mechanical condition of the clay soil. Further communication on this effect will follow later on.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 3) Magnesite ... | a. | 18 | 56.4 | 7.13 | 12.75 | 1.50 | 21.38 | | |
| | b. | 23 | 60.0 | 10 50 | 15.00 | 1.13 | 26.63 | 8.25 | 23.76 |
| | c. | 21 | 57.3 | 7.13 | 14.63 | 1.50 | 23.26 | | |
| 4) Magnesite + $Na_2SO_4.10H_2O$ | a. | 21 | 66.9 | 11.63 | 16.88 | 1.50 | 30 01 | | |
| | b. | 21 | 58.5 | 9.75 | 15.38 | 3.38 | 28.51 | 10.13 | 28.01 |
| | c. | 20 | 57.6 | 9 00 | 15.00 | 1.50 | 25.50 | | |

## (B). With general manure.

| Kinds of manure. | | No. of stalks. | Length of stalks cm. | Weight p. pot of Grains g | Stalks g | Chaff g | Total g | Average of Grains g | Total g |
|---|---|---|---|---|---|---|---|---|---|
| 1) No special manure | a. | 57 | 97.2 | 57.00 | 97.88 | 7.13 | 126.01 | | |
| | b. | 58 | 97.5 | 52.13 | 85.50 | 4.88 | 142.51 | 52.75 | 138.26 |
| | c. | 61 | 95.4 | 49.13 | 95.25 | 4.88 | 149.26 | | |
| 2) $MgSO_4.7H_2O$ .. | a. | 65 | 95.1 | 48.38 | 95.25 | 5.25 | 148.88 | | |
| | b. | 60 | 93.0 | 52.50 | 91.50 | 5.25 | 149.25 | 50.44 | 149.07 |
| | c. 1) | — | — | — | — | — | — | | |
| 3) Magnesite ... | a. | 62 | 87.0 | 53.63 | 91.88 | 6 38 | 151.89 | | |
| | b. | 60 | 90.0 | 45.38 | 94.88 | 5.25 | 145.51 | 47.50 | 147.26 |
| | c. | 56 | 97.5 | 43.50 | 95.63 | 5.25 | 144.38 | | |
| 4) Magnesite + ... $Na_2SO_4.10H_2O$ | a. | 73 | 95.4 | 49.13 | 99.75 | 7.88 | 156.76 | | |
| | b. | 64 | 97.5 | 50.25 | 87.00 | 6.38 | 143.63 | 49.50 | 146.76 |
| | c. | 58 | 99.0 | 49.13 | 86.25 | 4.50 | 139.88 | | |

1). The plants in this pot were damaged by fungus.

From these results we conclude :

1). An amount less than 0.02 % $SO_3$ in the three soils was quite sufficient to meet the requirements of the barley plants for sulphur. The difference in the harvests was too small to admit any other conclusion than this.

2). In the soil No. I and No. III the manuring with magnesia had no decisive effect ; this may have been due to the small differences of lime and magnesia contents in these soils.

3). Soil No. II[1] showed a very unfavorable mechanical condition being a very stiff clay and was probably very poor in potassa[2], while the amount of $P_2O_5$ was only 0.022%. Hence the addition of limestone to the un-manured soil had very little effect although the mechanical condition was improved, while with the manured soil the addition of limestone produced a surprising increase of barley grains from 1.25 g to 38.63 g.

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1). This soil was found afterwards to have a strong acid reaction on litmus, and since this soil contains only a little humus, the acidity would probably be due to acid silicates. Enormous increase of harvest by liming of this soil is therefore partly explained by the neutralization of the acidity. Many such acid soils occur in Japan and the result of investigation of these soils will be published later on.

2). A sample of soil taken from the same area contained only 0.088% $K_2O$.

# Chemical Composition of Tea Leaves at Various Stages of Development.

BY

**S. SAWAMURA.**

Tea prepared from very young leaves is of the best quality. But as the produce is not large tea is prepared in most parts from pretty well developed leaves. Therefore there may be species of tea prepared from the leaves varying from very young to very old. It is of some interest to know the relation of the development of tea leaves to their chemical composition. The relation of the development of vegetable leaves to their chemical composition has not hitherto been much studied. Höhnel[1] found, by investigating the relation between the water content and the development of leaves with 40 species of plants, that the water contents of leaves represents the maximum in the youngest stage of development. Fliche and Grandeau[2] found that with *Robinia pseudacacia*, *Cerasus avium*, *Castanea vulgaris* and *Betula alba*, the leaves became richer in ashes but poorer in water and nitrogen as they grew older. Kellner[3] gathered tea leaves twice a month from May to November and found that as the leaves grew older the water content decreased from 76.83% to 60.97%, and in dry matters crude protein decreased from 30.64% to 17.14%; theine from 2.85% to 1.00%; but ether extract increased from 6.48% to 22.19%; crude fiber from 9.10% to 18.34%; tannin from 8.53% to 12.16% and ashes from 4.69% to 5.04%.

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1). Centralblatt für Agrikulturchemie 1878, p. 911.
2). Centralblatt fär Agrikulturchemie 1877, p. 43.
3). Landw. Versuchrstationen Vol. 39.

The variation of chemical composition of tea leaves during a year was made clear by this investigation, but the variation during tea manufacturing period is still unknown. The writer therefore has undertaken to investigate this point. For this investigation it was not desirable to compare tea leaves picked at various stages of development in different periods, because there might be some disturbance resulting from climatical influences. Therefore in this investigation variously developed leaves of the young twigs bearing four leaves, the top one of which was of course in a folded state, were picked as is usual in tea harvest and analyzed. Crude protein was estimated by multiplying with 6.25 nitrogen found by Kjeldahl's method after reducting theine-nitrogen. Albuminoid-nitrogen was estimated by Stutzer's method; ether extract by reducting theine from that obtained by Soxhlet's method; crude fiber by Weende method; tannin by improved Loewenthal's method calculating 63 gr. oxalic acid = 38.3 gr. tannin; and theine by extracting the residue obtained by evaporating tea decoction with magnesia with ether.

The average length of the leaves and young twigs bearing them were as follows :—

| | |
|---|---|
| First leaves | not observed |
| Second „ | 3.08 c.m. |
| Third „ | 3.32 |
| Fourth „ | 3 82 |
| Twigs | 4.32 |

The proportion of the weight of the leaves and young twigs was as follows :—

| | Fresh state. | Dry state. |
|---|---|---|
| First leaves | 100 | 100 |
| Second „ | 203 | 208 |
| Third „ | 412 | 399 |
| Fourth „ | 577 | 534 |
| Twigs | 717 | 419 |

Chemical composition was as follows :—

In 100 parts of fresh substance.

| | Leaves. | | | | Twigs. |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| Water ... ... ... ... ... | 72.476 | 71.979 | 73.280 | 74.540 | 83.911 |

In 100 parts of solid matters.

| | Leaves. | | | | Twigs. |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| Crude protein ... ... ... ... | 41.238 | 42.044 | 34.016 | 30.153 | 28.400 |
| Ether extract ... ... ... ... | 6.981 | 7.903 | 11.354 | 11.428 | 8.027 |
| N-free extract ... ... ... ... | 18.397 | 13.651 | 18.499 | 20.728 | 26.957 |
| Crude fiber ... ... ... ... | 10.872 | 10.895 | 12.253 | 14.748 | 17.079 |
| Theine ... ... ... ... ... | 3.578 | 3.559 | 3.232 | 2.570 | 2.146 |
| Tannin ... ... ... ... ... | 13.965 | 16.960 | 15.779 | 15.438 | 11.142 |
| Ashes (free from C)... ... ... | 4.969 | 4.988 | 4.867 | 4.935 | 6.249 |
| Total N ... ... ... ... ... | 7.545 | 6.727 | 6.294 | 5.504 | 5.112 |
| Albuminoid N ... ... ... ... | 6.136 | 5.414 | 5.056 | 4.298 | 3.296 |
| Theine N... ... ... ... ... | 0.947 | 0.939 | 0.855 | 0.680 | 0.568 |
| Soluble { organic matter ... ... | 45 929 | 48.255 | 46.959 | 45.460 | 44.063 |
| Soluble { inorganic matter ... | 4.162 | 4.097 | 4.296 | 3.124 | 5.680 |

From these results we conclude that with the development of the tea leaves, water, crude protein and theine decrease, while ether extract, crude fiber and tannin increase. Solubility shows no regular variation with the development of the tea leaves.

The writer express his sincere thanks to Mr. T. Oshima who analyzed these samples of tea leaves.

# On the Aroma of Black Tea.

BY

**T. KATAYAMA.**

It is of great importance for the manufacture of black tea, to know by what agencies its agreeable aroma is produced. The so-called fermentation of tea is attributed by some authors to microbes by others however to the enzymes of the leaves. Bamber[1] denies the existance of a genuine fermentation having been unable to observe any microbe. Newton[2] supposes that the flavour of black tea is dependent upon the action of an oxidizing enzym in the tea leaf, but Crole[3] and other authors ascribe the fermentation at least partly to the action of certain micro-organisms[4].

Since I had observed frequently bacilli on the rolled tea leaves undergoing the fermenting process, I was led to suppose that some relations between these bacilli and chemical changes in the tea leaf might exist. Hence I tried to kill the ordinary microbes adhering to the leaves and to infect the leaves with bacilli taken from *fermenting* leaves.

Fresh tea leaves were left in ether for 4 hours, rolled and dried as usual. The green color of these leaves not only gradually changed to brownish but also the characteristic aroma of black tea was observed after 10 hours, in spite of the odor of adhering traces of ether.

This experiment shows that the aroma is not caused by any micro-

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1). Agriculture and chemistry of tea.

2). On tea, a publication from India.

3). Tea, its cultivation and manufacture.

4). Aso has observed that the black color of tea is caused by the action of the oxidase of the leaves upon the tannin present (Bul. College of Agriculture, Tokyo Imp. Univ., Vol. IV, No. 4).

organisms. The same result was obtained when the ether was substituted by alcohol and chloroform.

Also powerful antiseptics as cresol, mercurie chloride were tried Fresh tea leaves were soaked in a 4% cresol solution for 24 hours washed once with distilled water, dried in the sun and then rolled and kept compactly in a flask. The tea leaves changed gradually in color to brownish black and after 15 hours produced a distinct aroma modified however by the odor of traces of cresol remaining.

Fresh tea leaves were left in a 1% $HgCl_2$ solution for 20 hours, whereby the leaves assumed a pale appearance, and washed with distilled water. When kept in a flask, the characteristic aroma of black tea was also here observed after some time, but the blackening of the leaves was here not observed.

When the so-called fermentation process is allowed to go on for too long a time before drying or firing, the normal aroma produced, gradually disappears and a sour smell developes. Finally white mould appears on the leaves. However if the leaf is treated with antiseptics as above mentioned, the sour smell is not observed.

These tests render it very probable that the development of aroma is due to the action of certain enzymes originally present in the leaves which produce the specific volatile oil of tea from certain compounds. This is in analogy to the flavour of tobacco which is also produced by the action of enzyms (oxidases).

I have further observed that after treating tea leaves with cyanogen gas for 5 hours the aroma fails to appear.

When tea leaves are repeatedly treated with ether or alcohol, the aroma fails to develop which shows that those substances which yield the aroma have been extracted by ether and alcohol, which agrees with observations of Kozai[1].

Since Kozai, Bamber and other authors observed that black tea can not be manufactured from steamed tea leaves, I have tried the influence of

1). Bulletin College of Agriculture, Tokyo Imp. Univ., Vol. I, No. 7.

various lower temperatures. The tea leaves were kept at these temperatures for an hour and after having gone through the usual process the results were as follows :

| | |
|---|---|
| 40°C ... ... ... ... ... ... ... | good aroma. |
| 50 „ ... ... ... ... ... ... ... | „ „ |
| 60 „ ... ... ... ... ... ... ... | only a very weak aroma. |
| 65 „ ... ... ... ... ... ... ... | no aroma, only a raw grassy smell. |
| 75 „ ... ... ... ... ... ... ... | „ „ „ „ „ „ „ |
| 100 „ ... ... ... ... ... ... ... | „ „ „ „ „ „ „ |

This result supports my opinion, that the production of aroma is caused by a certain enzyme. As to oxidizing enzymes their presence can easily be demonstrated. When tea leaves are treated with strong alcohol until the tannin is entirely removed, and then treated with distilled water, the aqueous extract thus obtained behaves as follows :

| | Guaiac tincture. | Guaiac + $H_2O_2$. |
|---|---|---|
| 40 ... ... (aroma) ... ... ... ... ... | blue | deep blue |
| 50 ... ... ( „ ) ... ... ... ... ... | „ | „ „ |
| 60 ... ... (very weak) ... ... ... ... | „ | „ „ |
| 65 ... ... (no aroma) ... ... ... ... | „ | „ „ |
| 75 ... ... ( „ „ ) ... ... ... ... | no coloration | no coloration |
| 100 ... ... ( „ „ ) ... ... ... ... | „ „ | „ „ |

Since the leaves kept at 65° developed no aroma but gave still the reactions for oxidase and peroxidase, it appears that other enzyms than these are concerned in the production of aroma.

## POST SCRIPTUM.

As Mr. Katayama having had to break off his studies on account of his departure for India and Europe, Prof. SAWAMURA made a further experiment upon which he reports as follows :

"I extracted 156 g of fresh tea leaves with 900 c.c. of absolute alcohol and 147 g with 1 litre of 20% alcohol. The former extract was evaporated to dryness and the residue dissolved in water (A). The latter extract was precipitated with ether-alcohol (B). By adding the precipitate B

containing the enzyms to the solution (A), an agreeable aroma characteristic for the prepared tea was produced."

This result is a further confirmation of the view, that the tea aroma is caused by the original enzyms of the leaves. But the true nature of the enzymatic process requires further study. The most probable supposition is, however, that a peculiar enzym splits a certain glycoside present in small quantities and that one constituent thus liberated yields by taking up oxygen the aroma of tea. Y. Kozai.

# A Disease of the Japanese Ginseng Caused by Phytophthora Cactorum (Con. et Leb.) Schröt.

BY

S. HORI.

The Japanese ginseng (*Aralia quinquefolia A. Gr. var. Ginseng Rgl. et Mack.*) is at present chiefly cultivated in the northern part of this country : viz.—Fukushima, Nagano, Yamagata, Tochigi, Tottori, Shimane, and Hokkaido. The Dist. Shimane forms the southern limit of the ginseng culture and is celebrated for a superior article.

In the beginning of the summer of 1904, samples of the diseased ginseng plant were forwarded by Mr. S. Ema, the director of the Shimane Experiment Station to our Station for examination. Microscopic examination revealed the presence of the well known parasitic fungus *Phytophthora Cactorum* (*Cohn et Lebert*) *Schröter* by which the disease is evidently caused.

The disease is called locally *Koshi-ore* (bending at the loins) or *Koshi-nae* (paralyzing at the loins) according to the symptoms. It is said that the disease occurs more or less in the rainy season when the moist, warm weather has continued for some time. It was further reported that the disease was unusually destructive in May 1904, the damages being estimated to be about fifty thousand Yen ($ 25,000) in the limit of a small ginseng region of the Prov. Idzumo, Dist. Shimane.

I visited the Idzumo ginseng region at the end of March 1905, though the time was too early for the observation of the disease, because the ginseng plants had not yet come up above the ground. I recommended the growers to try the spraying of Bordeax mixture, the first time, as soon as the leaves unfolded, and if it becomes necessary on account of the weather, the second spraying about two weeks later.

Two months afterwards, I received the reports, forwarded by friends

in the Idzumo ginseng region, that the disease had broken out towards the 24th of April and the spraying of the Bordeaux mixture was very effective as it thoroughly stopped the spreading of the disease.

When I was studying the ginseng disease in the spring of 1905, I requested Prof. J. M. Van Hook, Wooster, Ohio, to send me his publication on diseases of ginseng and at the same time I sent to him a sample of the diseased ginseng which was forwarded by Mr. S. Ema, who collected it in Idzumo in May 1904. Soon afterwards he kindly furnished me his work together with the following very interesting information under the date of May 16, 1905. Prof. Van Hook writes:

"I am in receipt of yours of April 17th inclosing specimen of ginseng. Permit me to thank you for the same. It was something I had never seen before. However a very strange coincidence occurred in regard to that disease. In the same mail in which your plant came, was a package from Sewisburg, Ohio containing diseased ginseng. I had just read your letter and examined the specimen you sent affected with *Phytophthora Cactorum*. Noticing that the plants looked similar to the one you sent, I remarked to Prof. Selby "That looks like Mr. Hori's Phytophthora, doesn't it?" Well, a microscopic examination revealed the disease due to *Phytophthora Cactorum*. Spores measured 30—42=40—58 $\mu$. The man who sent us this material seems to think that it also killed his tobacco seedlings. We are now making a thorough investigation of the disease. It seems strange that this disease should never before have appeared here on ginseng, and then to make its appearance on exactly the day I received your letter. If your bulletin has not yet gone to press, you can add Ohio to the list of places in which it occurs on ginseng."

According to the opinion of the ginseng growers, it seems credible that the ginseng mildew had existed in the Prov. of Idzumo a long time ago, though there were some fluctuations of the outbreak, and it has been hitherto completely overlooked until 1904 when I investigated the nature of the disease. Until then there was no reliable record of the occurrence of *Phytophthora Cactorum* on ginseng either in Japan or in other countries.

According to the information of Prof. Van Hook just mentioned, *Phytophthora Cactorum* occurs also on American ginseng at Sewisburg, Ohio, where it was observed just one year after the discovery of the above fungus on Japanese ginseng. In connection with the above fact, another strange coincidence may be recalled, namely that the "cucumber downy mildew," which was first discovered by the late N. Tanaka in the vicinity of Tokio in July 1888, was discovered just one year later by Prof. Halsted in New Brunswik, New Jersey in May 1889.

## History of the Ginseng Disease.

Frank[1] was the first to describe a fungus on dying stems of *Panax quinquefolia*. The fungus was *Diplodia panacis* (*Fr.*) *Cook*, and entirely different from our fungus here mentioned. Prof. H. Garman[2] has noticed only that a rot destroys the wild root sometimes, without describing the fungus.

In 1900, Mr. T. Hanai[3] gave a short description on ginseng diseases "*Koshi-nae*," "root-rot" and "red-rot" in his report of our Exp. Station. His description of "*Koshi-nae*" disease is as follows:

> "It is a dreadful disease for the growers, the leaves and stems shrivel first, are then discolored and finally rot spreads down to the root. The disease is caused by some parasitic fungus and from its rapid infectious nature, it spreads quickly. When the leaves or stems are affected by the disease, the exposure of the upper portion of the root to the air is very advisable, otherwise the rotting would proceed to the root itself."

In 1903 Prof. G. C. Butz[4] also gave a short note on a disease of the American ginseng as follows:

> "The most serious loss may be caused by a fungus or several fungi usually present in wood soils. In consequence, a disease known as the "damping off" of seedlings and cuttings sometimes speedily attacks young ginseng plants at the surface of the soil, causing the stem to become soft and shrivel in a very short time. This disease

was found in some ginseng seedlings sent by Mr. N. B. Curstead, Olyphant Furace, Pa., in 1898. This fungus extends rapidly from plant to plant when they stand closely and in a single night may mow down an area of two or more square feet."

In 1904 Prof. Van Hook[5] published his work on the diseases of ginseng, in which he described and fully illustrated the "wilt disease" by the attack of *Acrostalagmus albus Pr.* and the "damping off" of seedlings by *Rhizoctonia sp.* Shortly afterwards he found one root-rot disease which he discovered was due to a fungus known as *Thielavia basicola Zopf*, and which he described and illustrated in Bulletin No. 156 of the Ohio Station.

So far as I know aside from his works nothing has ever been published in regard to a scientific investigation of ginseng disease.

Let us turn now to the brief history of *Phytophthora Cactorum* (*Cohn et Lebert*) *Schröter*.

In 1870 Cohn and Lebert[6] discovered this fungus occurring on Cactus stems, and named it *Peronospora Cactorum*. As it attacks many different plants, it was found and described as a new species respectively by different authors. Schrenk[7] found it on *Sempervivum* and gave the name *P. Sempervivi*. Hartig[8] has investigated this fungus more especially as a parasite attacking beech seedlings and gave the name *P. Fagi*. Shortly afterwards De Bary[9] observed the development of this fungus growing on cultivated *Sempervivum* and *Clarkia elegans* and changed the name to *Phytophthora omnivora*. Finally Schröter[10] changed the name more properly to *Ph. Cactorum* according to the priority of Cohn and Lebert.

As host plants Saccardo[11] has recorded only certain kinds of Cactus, A. Fischer[12], however, gives about 23 species of different plants.

Berlese[13] has enumerated the following 28 species of plants as the host of *Ph. Cactorum*:

Hab. in foliis plantarum variarum e gr. Cleomes violaceae, Fagopyri tartarici, F. marginati, Clarkiae eregantis, Schizanthi pinnati, Alonsoae caulialatae, et in plantulis (praecique in cotiledonis) Oenotherae biennis, Lepidii sativi, Salpiglossi sinuati, Epilobii rosei, vel in plantis carnosis in primis Cereo giganteo, C. speciosissimo, C. peruviano, Sempervivo

alvido, S. glàuco, S. stenopetalo, S. tectorum, Melocacto nigrotomentoso, vel demum in cotyledonis plantularum arborescentium nonnullarum et precique Fagi silvaticae, Aceris platanoidis, A. pseudoplatani, Fraxini excelsioris, Robiniae Pseudoacaciae, Pini silvestris, P. Laricio, P. Strobi, Laricis europeae, Abietis pectinatae etc. in Germania et in Italia.

Some years ago Prof. Massee[14] noticed that this fungus also attacks the cocoa pods in Trinidad and Ceylon.

The occurrence, however, of *Phytophthora Cactorium* on ginseng plants had thus far not yet been recorded.

## Symptoms of the Disease.

The disease is favored very much by continuous wet and warm weather at the time of the opening of the leaves and spreads destructively especially after a strong storm. The outbreak of the disease in 1904 and 1905 in Idzumo ginseng region clearly illustrates this fact. During the middle and latter part of April in 1904, the weather was damp and rainy. On the 27th and 28th an outbreak of the disease was noticed in some fields, but suddenly it became severe throughout the fields in the ginseng region 5 or 6 days after a strong storm with heavy rainfall on the 1st and 2nd of May. Just at this time the ginseng plants were opening their tender leaves, which suffered much mechanical injury by the storm and were thoroughly soaked by the rain, though the plants were sheltered by a straw-thatched roof inclining toward one side, and were surrounded by a straw fence on three sides, the north side being left open. In 1905, the weather in the middle of April having been also moist, a slight outbreak of the disease was noticed at that time in some fields. But one week after a strong storm raging from the 20th to the 22nd, it developed violently throughout the ginseng region. At the time of this last storm the ginseng leaves had not yet opened, mechanical injuries to the leaves therefore were somewhat lighter than in the previous year, while the young stems were considerably injured by the violent motions. In fact, the disease attacks the plants only in their

young stage but not after the attainment of full growth even when the conditions of the weather are favorable for the development of the fungus.

The most characteristic symptom of the disease is the wilting of the leaves, as the water supply is stopped. But close observation shows that pale colored spots first appear on the blades, petioles and on certain portions of the stem, and more occasionally on the attaching point of the leaves or leaflets to the axis before the leaves entirely shrivel. The spots soon enlarge and show a softening of these attacked tissues within a few days. Since this decaying process proceeds downward to the roots, the entire plant begins to wilt and drops to the ground. When the spots on the blades however stop their spreading under certain conditions unfavorable to the fungus, they assume a light yellowish color with irregularly rounded contour, and persist in this state for a long time. Occasionally a Fusarium mould begins to grow on the axial part of the attacked leaves and on the surface of the certain portions of the stem a white or light rose colored appearance is produced .

Ryzomes 1–2 years old are much less damaged than when 3–5 years old; the liability to attack increases with age. According to the information of Mr. Ema, the plants grown on well manured fields are also easily damaged.

## Cause of the Disease.

As already stated, the disease is caused by the well known parasitic fungus *Phytophthora Cactorum* (*Cohn et Lebert*) *Schröter* whose life history and infectious nature have been carefully studied by De Bary, Hartig and others. But that the ginseng plants also can form a host for this fungus is entirely new.

The fungus appears as a very delicate thin white mould almost insignificantly on the surface of the attacked plants. The conidiophores are simple, slender, delicate, colorless, 95$\mu$ in height, 7$\mu$ in diameter at broadest part, projecting out singly through the stomata or epidermis; branched ones are not found among my specimens. The spores are elliptical or ovate attaining the size of 30–50=50–60$\mu$, sometimes much larger and of abnormal form

29=85.5$\mu$, and are attached singly at the broad end to the conidiophore which soon liberates the spore when matured. The latter is thin walled, contents colorless, fine granular with some small oil globules; papillated at the apex and showing a small projection at the base by which the conidiophore is attached. The spore germinates under proper conditions of moisture and gives rise to a number of zoospores. The oospores are produced in the tissues of the diseased plants. They are spherical in form, 26–28$\mu$ in diameter, light brownish, thick walled; contents colorless, fine granular with some oil globules, loosely surrounded by the oogonium wall. Thus the form, size and other characters of the fungus essentially agree with the species observed in Europe.

When the spores transported by wind settle accidentally on the surface of a young ginseng plant, they rapidly germinate under favorable conditions to zoospores, and thus create a new center of disease. Although the conidiospores produced on a diseased plant are but few, yet since each individual spore gives rise to a large number of zoospores by germination, extensive fields of the ginseng plant are deadly infested by this disease within a few days. As already mentioned, the spread of the disease is much increased by strong storms with heavy rain fall. The fact that the disease develops principally at the point of the leaf axis, clearly shows that this particular spot is much suited for holding the spores which may be carried there by winds or washed down from the surface of the leaves by rain.

As the disease always occurs on young leaves, it seems that the full grown tissues resist the fungus though the weather may be favorable for its development.

The rottening of the diseased plants seems to be accelerated by the combined action of other fungi and bacteria which act as secondary parasites.

There exist several other diseases of ginseng caused by different fungi and bacteria a report on which will be given later.

## Prevention.

Though the growers of ginseng suffer annually great loss, they do not take any effective measures to prevent the disease. The only step is that they remove some soil from the upper part of the roots in the opinion that the rottening process would not spread to the roots.

I have proposed to the growers to spray with Bordeaux mixture at the proper season, and indeed this treatment was a great success. The proposed Bordeaux mixture consisted of:

| | |
|---|---|
| Copper sulphate ... ... ... ... ... | 1 pound. |
| Quick lime ... ... ... ... ... ... | 1 pound. |
| Water ... ... ... ... ... ... ... | 10 gallons. |

Some growers sprayed 4 or 5 times, but experience showed that 2–3 times spraying suffices. Since the plants are sheltered by a roof and fences the sprayed mixture adheres to the plants for a long time without being washed off by rains, only heavy storms would render an additional spraying, necessary. My advise was as follows:

Spray Bordeaux mixture at least 10 days before the leaves open and apply a second dose at just the time when they open. The third spraying depends upon the conditions of the weather; about 10 days after the second spraying will be convenient.

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## Explanation of figures.

PLATE XXVII.

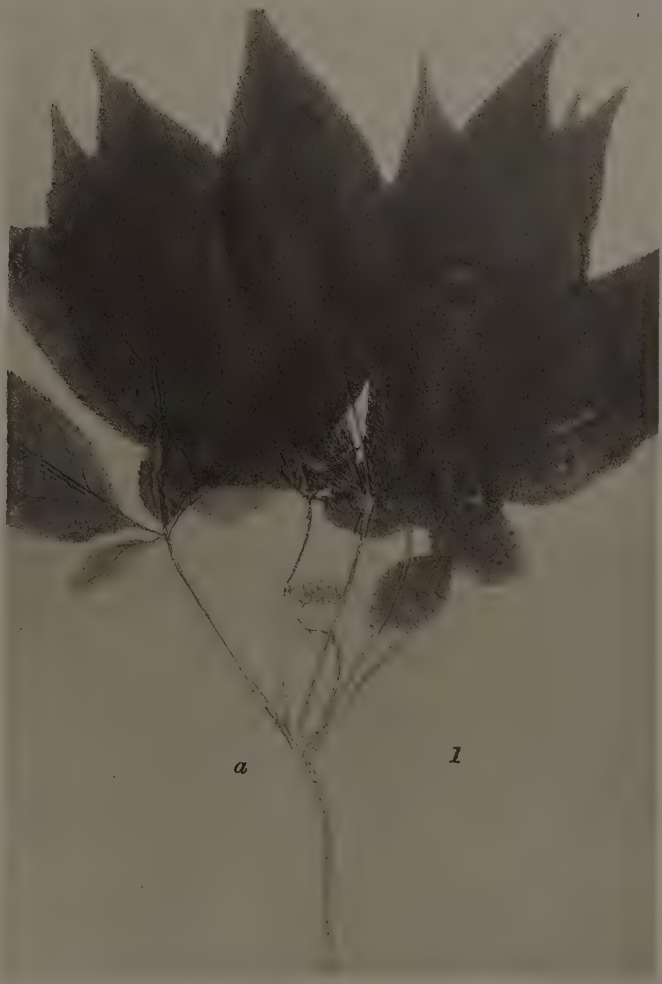
Fig. 1. Photograph of a diseased ginseng plant slightly reduced, *a* directly attacked part, showing the white moulded and shrivelled tissue.

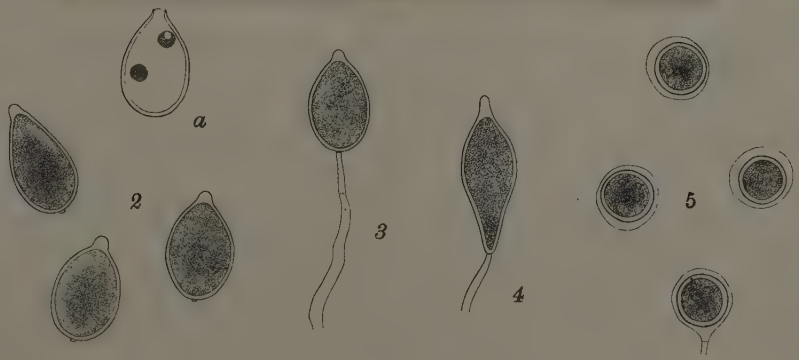
Fig. 2. Spores of *Phytophthora Cactorum*. *a*. A germinated spore containing 2 zoospores. (Zeiss 4 × DD.)

Fig. 3. Spore attached to the conidiophore. (Zeiss 4 × DD.)

Fig. 4. Abnormal spore. (Zeiss 4 × DD.)

Fig. 4. Oospores. (Zeiss 4 × DD.)




S. Hori Photo. et del.

# Seed Infection by Smut Fungi of Cereals.

BY

S. HORI.

By what manner smut fungi gain access to their respective host plants has been carefully studied by Kühn, Wolf and especially by Brefeld, but some points regarding the modes of natural infection are not yet fully understood. The present knowledge concerning the modes of natural infection by various smuts of cereals may be summarized as follows :

1. *Soil infection :* smut spores which found their way into the ground, infest the young sprouts or seedlings of the host.

2. *Flower infection :* smut spores after being carried into the flowers of the host by wind, germinate and remain as mycoplasma in the inside of the seed.

3. *Wind infection :* certain smut spores or sporidia will develop not only in flowers but also on any young tissue of the plant to which they had been carried by wind.

4. *Seed infection :* Such kinds of smut spores which cannot be easily scattered by wind or rain, may become attached to the seed coat during thrashing.

In order to observe whether spores in the soil infest the host, I have tried many experiments during the last 5 years. The smut fungi, the spores of which were used for soil infection, were *Ustilago Tritici*, *U. Hordei*, *U. nuda*, *U. Sorghi*, *U. Reiliana*, *U. Crameri*, *U. Panici-miliacei*, *U. Maydis*, *Urocystis occulta* and *Tilletia laevis*. After thoroughly mixing these with the soil, seeds of the respective host plants were sown in different intervals partly on the same day, partly after 5 or 10 days. But the results were always negative and no difference with the control plants was noticed.

By these experiments it became clear that the spores in the soil do not infest the host plants, and if such a case should happen, it would be a very rare one, at least in Japan.

While I was writing this article, Brefeld's Brandpilze IV reached us in which he also reports negative results of 3 years experiments (1903–1905) in the infection of several substrata (fresh horse dung or barnyard manure mixed with soil) with the spores of wheat and barley smut. His most recent experiments show that his former opinion of an increase of the smut disease by the application of fresh horse dung is erroneous. This agrees also with my experience in Japan. It is true that the most Japanese farmers do not use fresh horse dung for wheat and barley. They use fish guano, human excreta, rice bran, and to some extent compost manure containing rice straw. Yet the damage by smut may often amount to a loss of 10–20%.

Wheat and barley are sown in Japan in October-November and harvested in the following May or June. It is a peculiar phenomenon that if the seeds are sown early in the season the smut proportionally increases and vic. versa; this fact has been experimentally proved already. In consequence, the smut is comparatively rare on wheat and barley cultivated in the rice field, because the labour of harvesting rice, draining, plowing and drilling delays the sowing at least 1 to 1½ months. That fact is undoubtedly due to the difference between the germinating temperature of the smut spore and that of the seeds. Though the seeds are sown late in November, yet they germinate, but for germination of the smut spores adhering to the seed coat or the development of smut germs in the seed, the soil temperature is already too low.

The fact that the occurence of the smut relatively decreases as the time of sowing becomes later and that there is no such tendency observed in summer wheat and barley, proves that the smut spores in the soil remain in an inactive condition.

Another very interesting fact, which clearly proves that the spores of smut fungi present in the soil are not the active source of the natural infection, was observed some years ago with the smut of Italian millet and sorghum in the field of our Experiment Station. The seeds of the last

mentioned plants were introduced directly from Manchuria in 1890 and in 1904, and were sown in the field of the Station. In the autumn of the respective year, about 50% of Italian millet and 10% of sorghum were smutted. Since the smut of Italian millet (*Ustilago Crameri*) is in Japan very rare and only known in a limited area in the province of Shinano, and since the smut of sorghum (*U. Sorghi*) is still rarer and as I had not yet observed the smut on Japanese sorghum, I concluded that the spores of these smut fungi must have been introduced with the seeds of the respective host plants.

The second problem relates to the question whether the spores brought inside of the flowers may be infective or not. Mr. S. Nakagawa[1] of our former Branch Station at Matsuto (near Kanazawa city, the Prov. of Kaga) carried out an Experiment on this point early in 1897. He introduced the matured spores of *U. Tritici* into the flowers of wheat in the same field by means of a forceps. The infected seeds were sown in the ordinary time of the autumn of the same year. In the following year the ears, as soon as they appeared, were found to be all smutted. Similar experiments made by Mr. K. Yamada gave the same result.[2] Soon afterwards I obtained similar results in flower infection with *U. Tritici* and *U. nuda*. Hence I concluded that the spores of those smuts which mature at the flowering time of the host and may be scattered easily by the wind, will be retained in the innerside of the seed and give rise to the smut disease during the next flowering time of the host plant.[5]

Moreover, the above conclusion was also proved afterwards by Brefeld[3] and Hecke.[4] The latter author has clearly shown microscopically the presence of smut germs in the form of mycoplasma in the tissue of the embryo of the seed which matured after artificial flower infection. Hence, it is now clear that at least *Ustilago Tritici*, *Us. nuda* and *Us. Hordei* may naturally infest the respective host plants by the flower infection.

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1). Bull. Agr. Expert. St. Nishigahara, Vol. XII, No. 4, 1898. (Japanese.)

2). Rep. Local Agr. Soc. Kioto, 1896. (Japanese.)

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4). Untersuch, a. d. Gesammt. d. Myk. XIII, 1905.

5). Zur Theorie d. Blüteninfection des Getreides durch Flugbrand. (Berichte d. deutsch. Bot. Gesell. XXIII. Heft 6, s. 248. Taf. VIII, 1905.)

In regard to wind infection, Brefeld[1] was the first who proved it experimentally with Indian corn smut. Since the latter smut may occur on any part above ground of the host, the character is quite different from that of the other smuts of cereals. He sprayed the sporidia of the smut on the young inflorescence, leaves, growing point and air roots of the host and succeeded to produce the smut blisters on any intended part. The Indian corn smut (*Ustilago Maidis*) can therefore infest any part of the host by wind, the only example among the numerous smuts of cereals.

In regard to the fourth question, whether the spores of smut fungi attached to the seed coat of the host plants are infective or not, I have tried many experiments, some of which have not yet been finished. The smut fungi used for seed infection were *U. Tritici*, *U. nuda*, *U. Hordei*, *U. Reiliana*, *U. Crameri*, *U. Panici-miliacei*, *Tilletia laevis*, and *Urocystis acculta*.

All the seeds used in the experiments were disinfected by the hot water treatment[2] before the spore infection was carried out. That this hot water treatment prevents thoroughly the smuts above enumerated has been experimentally proved here already. The disinfected seeds, after being a little moistened with distilled water, were thoroughly mixed with the smut spores until the surface became brownish, and were directly sown in the usual manner at the proper season.

In spite of numerous trials, the seed infections with the spores of *U. Tritici*, *U. nuda*, *U. Hordei* and *U. Reiliana* yielded always negative results, while on the contrary the experiments with the spores of the following smut fungi always yielded positive results. The details will be described below.

## I. Infection of Italian millet (*Setaria italica var. germanica*) with *Ustilago Crameri*.

### A. Experiment in 1896.[3]

On account of the absence of smut on the Italian millet in the vicinity

1). Untersuch. a. d. Gesammt. d. Mykologie, XI, 1895.

2). The seeds after being soaked for 7 hours in cold water were kept some minutes in water of 50°C and then immersed for 5 minutes in water of 55°C.

3). Bull. Expert. Station, Nishigahara, Vol. XI, No. I. (In Japanese.)

of Tokio, seed (var. *Wase*) from a field, in the Prov. of Nagano about 100 miles north west from Tokio, where the smut had caused much injury in the previous year, were used for the experiment.

Before sowing the seed, the latter was tested by the following method to see whether smut spores were attached to the seed coat or not. Ten grains were thoroughly washed with distilled water which was then evaporated. Thirty-eight spores were thus observed under the microscope. This proved clearly that the smut spores became attached to the seed coat by careless thrashing in the presence of smutted ears.

On July 2 this seed was sown in a plot of 108 square feet and at the same time a variety of *Akita* raised on our Station field also was sown in a check plot. At the harvesting time, September 25, 144 ears of *Wase* were observed smutted, while no smut at all was on *Akita*.

### B. Experiment in 1897.[1)]

The smutted ears collected in the plot of the infection experiment carried on the previous year and preserved in a paper pocket, were gently ground in a mortar to break up the spore masses and the latter were then mixed with moistened seeds of *Wase* and *Akita* millet. These seeds were sown July 10 and the plants harvested October 1. The result was as follows :

| Variety. | Remarks. | Area of a plot. | No. of the healthy ears. | No. of the smutted ears. | Percentage of the smutted ears. |
|---|---|---|---|---|---|
| Wase 1 | mixed with the smut spores | 216 sq. ft. | 247 | 1234 | 83.3 |
| „ 2 | „ | 324 „ | 386 | 1851 | 82.7 |
| Akita | „ | „ | 116 | 459 | 87.4 |
| Wase | check | „ | 1394 | 80 | 5.4 |
| Akita | „ | „ | 758 | 0 | 0 |

1). Bull. Expt. St. Nishigahara, Vol. XIII, No. I. (In Japanese.)

## C. Experiment in 1898.[1]

The experiment carried on the previous year was repeated with the seeds of Wase and Akita millet. The seeds were sown July 5 and the plants harvested September 21. The result was as follows:

| Variety. | Remarks. | Area of a plot. | Sound ears. | Smutted ears. | Percentage of the smutted ears. |
|---|---|---|---|---|---|
| Wase | mixed with the smut spores | 108 | 374 | 324 | 46.4 |
| Akita | „ | „ | 304 | 266 | 46.6 |
| Wase | check | „ | 311 | 9 | 2.8 |
| Akita | „ | „ | 386 | 12 | 3.0 |

In this year the smut not only appeared to a small extent on the check plot of both *Wase* and *Akita* millet, but it was found also on some other varieties of millet in the experiment field (20 varieties were cultivated) on which the smut had not been observed before. But it was soon discovered that this unexpected result was due to negligence since the mats and implements which had been used for harvesting and thrashing the infected millet of the year before, had been used without previous disinfection.

For determing exactly the percentage of the smutted ears produced by the spore infection in the plot, the thinning process was not carried out. On this account, the growth of the millet plants was very irregular, most of which beared no seeds. Moreover, the smut being concealed entirely in the inside of the seed coat for a long time, it requires the greatest care and experience to recognize smutted ears especially when unripe. This difficulty was the cause of the smutted ears being thrashed together with sound ones.

*Conclusion:* By the results obtained during the last 4 years it was therefore decidedly proven that the smut of Italian millet is produced by

1). Bull. Expt. Station, Vol. XV, No. I, Nishigahara, 1899 (Japanese).

the spores adhering to the seed coat, where they have been carried by uncautious treatment in harvesting and thrashing or to some extent by the wind while the plants are standing in the field.

## II. Infection of wheat with *Tilleti laevis*.

### A. Experiment in 1898.[1)]

Bunt or Stinking smut of wheat caused by *Tilletia Tritici* or *T. laevis* is entirely absent in the vicinity of Tokio, but it may occur to a small extent in some localities of Japan. The smut for my infection experiments was obtained 2 years ago (Feb. 1896) from a grower in the Prov. of Shinano and was preserved in the herbarium in a paper pocket. The smutted grains were carefully ground in a mortar to break up the spore masses and the spores were then mixed with moistened seeds of wheat (d'Australie). These seeds were sown October 31 and the plants harvested June 9 in the following year. The result was as follows :

| Remarks. | No. of seeds sown. | Area of a plot. | No. of smutted ears. |
|---|---|---|---|
| Seeds mixed with spores ... | 3000 | 324 sq. ft. | 430 |
| Check ... ... ... ... ... | „ | „ „ | 0 |

Further the number of diseased plants was examined in order to show how many seeds are infected and how many ears were produced from the infected seeds. The result was as follows :

| No. of seed sown mixed with the spores. | No. of actually infested seeds. | Percentage of infected seeds. | No. of ears produced from infected 164 grains. | |
|---|---|---|---|---|
| | | | Smutted. | Sound. |
| 3000 | 164 | 5.46 | 430 | 58 |

1). Bull. Expt. St. Nishigahara 1901, No. XVIII (Japanese).

## B. Experiment in 1904.

The smutted grains for these experiments were obtained from the Breeding Farm in the Prov. of Shimosa belonging to the Imperial Court. The original seeds (*Ishima*) came from the Prov. of Idzumo in 1903, which had suffered great damages by the smut. Repeated experiments showed that the most spores of the smut had lost their germinating power. The wheat grains raised in our Station field were nevertheless mixed with these spores and sown Nov. 1. The wheat was harvested June 15, 1905 with the following result:

| Remarks. | Area of a plot. | Number of smutted ear. |
|---|---|---|
| Seeds mixed with spores ... ... ... | 324 sq. ft. | 92 |
| Check ... ... ... ... ... ... ... | „ „ | 0 |

The comparatively small number of the smutted ears clearly shows that the smut spores for the most part had lost their infective power owing to an uncautious preservation of the sample. But nevertheless the result agrees as a whole with that of the previous experiments.

## C. Experiment in 1905.

The smutted grains produced in the plot of the previous infection experiment and preserved in a paper pocket, were carefully ground and mixed with moistened wheat grains (*Fultz*). These seeds were sown October 27, 1905 and the plants harvested June 8, 1906. The result was as follows:

| Remarks. | Area of a plot. | Number of smutted ear. |
|---|---|---|
| Seeds mixed with spores ... ... ... | 324 sq. ft. | 827 |
| Check ... ... ... ... ... ... ... | „ „ | 0 |

From the results obtained in the last 3 years we may conclude the following:

1. Stinking smut of wheat is produced by the spores adhering to the seed coats. Uncautious thrashing is the only possible way by which the spores reach these spots.

2. Three years old spores still possess infective power.

3. Infected grain produces mostly smutted ears, but often healthy ears are also found among them.

## III. Infection of Wheat with *Urocystis occulta, Rabenh.*

### A. Experiment in 1898.[1]

The smut produced by the attack of *Urocystis occulta* being most abundant on rye is commonly known as rye smut or Roggenstengelbrand, but this smut also occurs occasionally on oats and barley in Europe and has been found according to Wolf on wheat in Australia. In Japan I first observed this smut on wheat in the vicinity of Ōita in Kiushu in 1895. Since then it has also been found in several other localities on wheat, but not yet on barley, oats or rye. The latter two kinds of cereals, however, are seldom cultivated in Japan. The most noticeable outbreak of this smut on wheat was observed in 1898 in a field in the Prov. of Kai where all plants of an area of about ¼ of an acre were entirely destroyed before flowering time. But such great damage to wheat is thus far an exceptional case.

The smut spores for my infection experiments were obtained from the smutted wheat just mentioned, by slightly shaking the plants. The spores were then mixed with the moistened grains (d' Australie) which were sown October 30 The plants were harvested June 6 in the following year. The result was as follows :

| Remarks. | Number of seeds sown. | Number of smutted plants. |
|---|---|---|
| Seeds mixed with the spores. ... ... | 3000 | 1347 |
| Check ... ... ... ... ... ... ... | ,, | 0 |

1). Bull. Nishigahara Expt. St. No. XVIII, 1901 (Japanese).

Furthur it was noted how many plants were smutted, showing the number of the actually infested seeds. The result was as follows :

| No. of seed sown. | No. of seeds produced the smutted plants. | No. of plants produced from the actually infested seeds. | |
|---|---|---|---|
| | | Smutted. | Healthy. |
| 3000 | 440 | 1347 | 1042 |

## B. Experiment in 1899.

The smutted plants produced in the plot of the previous infection experiment and preserved in a paper pocket, served in the same way for the following experiment. The infected seeds were sown October 31 and the plants harvested June 30 in the following year with the following result :

| Remarks. | Number of seeds sown. | Number of smutted plants. |
|---|---|---|
| Seeds mixed with the spores ... ... | 3000 | 1534 |
| Check ... ... ... ... ... ... ... | „ | 0 |

How many seeds sown produced smutted plants is seen from the following table :

| No. of seeds sown. | No. of seeds produced the smutted plants. | No. of plants produced from the actually infested seeds. | |
|---|---|---|---|
| | | Smutted. | Healthy. |
| 3000 | 504 | 1534 | 1256 |

*Conclusion :* These two years experiments decidedly prove that the smut is produced by the spores of *Urocystis occulta* adhering to the seed coat whither they have been carried by careless thrashing. But it may be possible to some extent, that the matured spores, being easily scattered by winds, could also reach the innerside of the flowers and thus may be kept until thrashing time.

Infected grains produced both smutted and healthy plants nearly in the ratio of 3 : 2 without reducing the power of off-shooting.

## IV. Infection of Millet (*Panicum Miliaceum*) with *Ustilago Panici-miliacei* (*Pers.*) *Winter*.

### A. Experiment in 1899.[1]

In August 1898, a farmer in the Prov. of Tokachi, Hokkaido sent to our Station some specimens of millet smut which year after year had caused great damage leading sometimes to the entire loss of a harvest, and asked for a proper method of prevention. Until then millet smut had never been reported, though millet is commonly cultivated throughout Japan. But according to recent researches, it becomes clear that millet smut is restricted to Hokkaido and to some localities of Mutsu, the northernmost province of Hondo (Main island) of Japan. The specimens received astonished us, and led us to a series of experiments in 1899.

The smutted panicles were carefully ground and then mixed with the millet seeds raised in our Station field. The seeds were sown July 10 and the plants harvested August 23. The result was :

| Remarks. | Area of a plot. | No. of smutted plants. |
|---|---|---|
| Seeds mixed with spores ... ... ... | 288 sq. ft. | 567 |
| Check ... ... ... ... ... ... ... | ,, ,, | 0 |

The appearance of smutted panicles closely resemble that of Sorghum smut (*U. Reiliana*), but the difference is that the smutted panicles covering the shinning white membrane, are concealed for a longer time between the green leaves and that the infested plants remain of a greenish color, while the healthy plants become yellowish in ripening. When the main panicle was smutted, the secondary panicles, beginning to grow from the lower leaf-axis, were all found smutted too.

1). Bull. Nishigahara Expt. St. No. XVIII, p. 10, 1901 (Japanese).

B. Experiment in 1900.

Smutted panicles from the previous infection experiment, served now for the next experiment. The seeds were sown July 6 and the plants harvested August 20. The result was :

| Remarks. | Area of a plot. | No. of smutted panicles. |
|---|---|---|
| Seeds mixed with spores ... ... ... | 360 sq. ft. | 791 |
| Check ... ... ... ... ... ... ... | ,, ,, | 0 |

C. Experiment in 1906.

The smut spores for the experiment were two years old and obtained from Hokkaido Experiment Station. Two grams of these spores were mixed with 45 grams of millet seeds which were then sown July 10. The plants yielded, on being harvested September 27, the following result :

| Remarks. | Area of a plot. | No. of ears. | |
|---|---|---|---|
| | | Smutted | Healthy |
| Seed mixed with spores ... ... ... | 468 sq. ft. | 3135 | 3160 |
| Check ... ... ... ... ... ... ... | ,, ,, | 0 | not counted |

*Conclusion :* By these three years experiments it becomes evident that the millet smut is produced by the spores of *Ustilago Panici-miliacei* adhering to the seed coat whither they have been carried by careless thrashing. This was clearly proved also by the following facts. The millet in central and southern Hondo is commonly harvested by cutting the ripened, healthy panicles only, so that there is no occasion for the smut spore adhering to the seed coat in thrashing. In Hokkaido, however, the entire millet plants are cut near the ground regardless of disease and then thrashed ; thus the smut spores of the smutted panicles, can adhere to the seed coat. Hence the real cause of millet smut being restricted to Hokkaido is clear.

In 1902, Mr. Y. Takahashi[1] of the Hokkaido Agricultural Experiment Station in Sapporo, carried out also such infection experiments with the millet seeds and smutted panicles also obtained from the Prov. of Tokachi. The result of his experiment was :

| Remarks. | Area of a plot. | No. of smutted plants. |
|---|---|---|
| Tokachi millet seeds ... ... ... ... | 360 sq. ft. | 465 |
| Same seeds mixed with spores ... ... | ,, ,, | Almost all the plants were smutted. |

This result essentially agrees with mine.

In addition, a few words may be permitted as regards the infection experiments with millet smut by Brefeld.[2] His method does not decide the present question whether the smut spores adhering to the seed coat are infective or not. He sprayed the germinated spores on very young millet seedlings and for securing the inoculation the latter were kept one week under a cover, and then transplanted to the field. By this method he obtained 60–70% of smutted plants.

## Summary.

Soil infection, although known in other cases, does not generally take place by the smuts of cereals ; such a case would constitute surely a very rare exception, at least in Japan.

The smuts of cereals may be classified as follows according to their respective mode of natural infection :

| | |
|---|---|
| Ustilago Tritici. | Flower infection. |
| ,, Hordei. | ,, |
| ,, nuda. | ,, |
| ,, Maidis. | Wind infection. |
| ,, Panici-miliacei | Seed infection. |
| ,, Crameri. | ,, |
| ,, Reiliana. | ,, ? |
| ,, Sorghi. | ,, ? |

1). Bull. Hokkaido Agr. Expt. St. No. I, p. 112, 1902 (Japanese).
2). Untersuch. a. d. Gesammt. d. Myk. Heft XIII. p. 59, 1905.

| | | |
|---|---|---|
| Ustilago Avenae. | Seed infection. | ? |
| „ laevis. | „ | ? |
| Urocystis occulta. | „ | |
| Tilletia laevis | „ | |
| „ Tritici. | „ | ? * |

* The interrogation mark signifies that the experiments with the particular smuts are not yet finished.

# A Synoptical List of Coccidæ of Japan with Descriptions Of Thirteen New Species.

BY

S. I. KUWANA.

## Introduction.

In this paper are listed 97 species of Coccidæ in Japan, which were collected, during the past three years, by the writer and other members of the Division of Entomology, in the Imperial Agricultural Experiment Station, and were studied by the author. Thirteen of these species are new and are described under the following names:

*Icerya okadae.*
*Cerococcus muratae.*
*Kermes vastus.*
*Kermes miyasakii.*
*Eriococcus lagerstroemiae.*
*Dactylopius takae.*
*Ripersia japonica.*
*Ripersia oryzae.*
*Aclerida (?) biwakoensis.*
*Pulvinaria kuwacola.*
*Lecanium kunoensis.*
*Lecanium glandi.*
*Lecanium nishigaharae.*

## FAMILY COCCIDAE.

### Subfamily Orthezinae.

Genus Orthezia Basc.

1. *Orthezia Sp.*

Hab. In Japan, on *Polygonum* (Tade).

### Subfamily Monophlebinae.

Genus Monophlebus Burm.

2. *Monophlebus maskelli* (ckll.).

Monophlebus burmeisteri Mask. (Not Westw.), N. Z. trans., XXIX, p. 327, (1892).

„ „ Kuw. (Not Westw.), Pr. Cal. Ac. Sci., (3), iii, p. 46, (1892).

„ maskelli Ckll., Science, N. S., XV, p. 718 (1902).

Hab. In Japan, on *Aegle sepiaria* (karatachi), wild grapes, cherry, mulberry, orange, *Zelkowa acuminata* (keyaki), *Thea sasanqua* (sazanka) and pine.

3. *Monophlebus corpulentus* (Kuw.).

Monophlebus corpulentus kuw., Pr. Cal. Ac. Sci., (3), iii, p. 46, (1902).

Hab. In Japan, on Quercus Sp.

Genus Icerya Sig.

4. *Icerya okadae* N. Sp. (Pl XXVIII, Figs. 1–10).

*Adult female:*—Length about 5 mm. oval in shape; slightly narrower toward anterior end. On the margins of the body are rows of cottony fringes, and the dorsal aspect with three longitudinal rows of cottony projections; they are snow white with the yellow tips. Many long, silverly hairs on dorsal aspect. The egg sac is snow white.

Antennae are composed of eleven segments, about 1 mm. in length;

terminal segment the longest; second and third segments are next; the others subequal; each segment bears many long hairs. Legs subequal; tarsus not longer than one half the length of the tibia; claw long, slender, slightly curved, bears two spiny digitulules at the base.

*Newly hatched larva:*—Length 1 mm., width 0.5 mm., oval in shape; antennae are composed of six segments; the sixth segment is longer than the rest, and club-shaped; all the segments except the first have a few hairs, while the sixth has several, of which four are very long. Legs long and slender; tibia a little longer than the tarsus. Posterior end of the body has six long hairs.

Hab. In Japan, on orange tree.

## Subfamily Margarodinae.

### Tribe Xylococcini.

Genus Sasakia Kuw.

5. *Sasakia quercus* Kuw.,

Sasakia quercus Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 47 (1902).
,, quercus Ckll., The Ent., XXXV, p. 258, (1902).
Kuwania Ckll., in litt., (1902).
Hab. In Japan, on *quercus myrsinaefolia* (Shiragashi) and *quercus acuta* (katagi).

## Subfamily Coccinae.

### Tribe Asterolecanium.

Genus Lecaniodiaspis Targ.

6. *Lecaniodiaspis quercus* (Ckll).

Lecaniodiaspis quercus Ckll, Psyche, vii, supple., i, p. 19 (1896).
,, ,, ,, Bull. 4 T.S. Dep. Ag., U.S.A., p. 51 (1896)
,, ,, Kuw. Pr. Cal. Ac. Sci., (3), iii, p. 48 (1902).
Hab. In Japan, on *Quercus acuta*, *Q. sessilifolia* (Tsukubanegashi) and *Pasania glabra* (Mate-gashi).

## Genus Asterolecanium Targ.

### 7. *Asterolecanium variolosum var. japonicum* (Ckll).

Asterolecanium variolosum var. japonicum Ckll., Psyche, ix, p. 71 (1900).

Hab. In Japan, on *Quercus glandulifera* (kunugi).

## Genus Cerococcus Comst.

### 8. *Cerococcus muratae* N. Sp. (Pl. XXIX, Figs. 11–17).

♀ *Test:*—Length 5 to 6 mm., width 4 to 5 mm., height about 3 mm. barnicale-shaped, with several white bands which are radiate from the cone; mounted with reddish brown exuvia. Subtransparent brownish red in color. Posterior end of the test bears a tube-like projection.

*Adult female:*—Length 4 to 5 mm; regular in outline and ballon-shaped. The terminal segment of the body is the only one that is plainly distinguished from the others; it is strongly chitinized, and ends with two prominent lobes; each lobe has a long spiny hair at its extremity and bears several short ones on its inner margen. Mouth parts large, well formed. Antennae rudimentary, conical in shape, bear several short hairs. Legs wanting, spiracles prominent. Skin has many figur-8-shaped pores. Anal opening very large, with 8 long prominent hairs.

*Newly hatched larva:*—Length 532 $\mu$, width 200 $\mu$., elliptical in form, and distinctly segmented; the tip of the abdomen is furnished with two lobes, each terminating with a long hair. Anal opening is placed between these two lobes and is surrounded by several long hairs. Four longitudinal rows of Figure-8-shaped pores on the dorsum. Mouth parts well formed; lostal loop very long; mentum conical in shape. Antennae are composed of six segments; the third segment the longest, the other subequal. Legs well developed, tibia more than twice as long as tarsus; claw large and slightly curved. Posterior end of the body ends with two lobes, each of which bears a long hair.

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The name of this species is honor to Mr. Tohichi Murata of this station, who assisted me in my work in many ways.

Hab. In Japan, on *Viburnum odoratissimum* (sango-ju), and grape.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

## Tribe Kermesini.

### Genus Kermes Boitard.

9. *Kermes nakagawae*.(Kuw.).

Kermes Nakagawae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 49 (1902).

Hab. In Japan, on *Quercus glandulifera*.

10. *Kermes nawae* (Kuw.).

Kermes nawae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 49 (1902).

Hab. In Japan, on *Quercus glandulifera*.

11. *Kermes vastus* N. Sp. (Pl. XXIX, Figs. 18–21).

*Adult female:*—Diameter 8 to 10 mm., vary globose in form, with a very slightly longitudinal groove on the meson; shiny, chestnut brown in color, with black bands; when taken off the specimens from the host, leaves behind a little cottony white secretion. Antennae very short; composed of seven segments; the first and second segments subequal and the longest; fourth segment next to the longest: sixth and seventh segments subequal and the shortest. Legs small; femur slightly longer than tibia; tarsus shorter than tibia and tapering toward the posterior extremity; claw short and curved. Mouth parts large, well chitinized; mentum rather large, conical in shape; rostral loop very long.

Hab. In Japan, on *Quercus glandulifera*.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

12. *Kermes miyasakii* N. Sp. (Pl. XXIX, Figs. 22–28).

*Adult female:*—4 to 5 mm. in diameter; globose in farm; shiny dark brown in color, with several transverse black bands; slightly covered with a waxy secretion. Exuvia is found on the dorsum. Antennae rudimentary,

about 95 $\mu$. in length, and are composed of five segments; second segment the longest, almost as long as all the others taken together. Legs very rudimentary; femur not very much longer than tibia.

*Newly hatched larva:*—380 $\mu$. in length; oval in form, with segmentation distinct. Antennae are composed of six segments, about 85 $\mu$.; sixth segment the longest. Mouth parts large, well chitinized; rostral loop more than twice as long as the length of the body. Legs well formed; tarsus longer than tibia. Posterior end of the body is divided into two lobes, each of which bears a long spiny hair and many spines.

Hab. In Japan on *Quercus serrata.*

Type in the entomological collection of the Imperial Agricultural Experiment Station.

## Tribe Eriococcini.

### Genus Eriococcus Targ.

13. *Eriococcus graminis* (Mask).

Eriococcus graminis Mask., Ent. mm., xxxiii, p. 243 (1897).

„ „ Kuw., Pr. Cal. Ac. Sci. (3), iii, p. 50 (1902).

Hab. In Japan, on bamboo.

14. *Eriococcus onukii* (Kuw).

Eriococcus onukii Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 51 (1902).

Hab. In Japan, on bamboo.

15. *Eriococcus japonica* (Kuw.).

Eriococcus japonica Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 5 (1902).

Hab. In Japan, on *Symplocos myrtacea* (Hainoki).

16. *Eriococcus lagerstroemiae* N. Sp. (Pl. XXX, Figs. 29–33).

*Adult female:*—Enclosed in oval sac about 6 mm. long and about 3 mm. wide; snow white in color.

Body, oval or broad elliptical in form, very plump, about 4 mm. in length, dark purple in color; dorsum has very spiny hairs. Antennae have

seven segments; second and third segments subequal, and the longest; each segment bears a few rather long spiny hairs. Legs subequal, comparatively small; tarsus a little longer than tibia. Posterior end of the body is turminated with two conical lobes, each of which bears a long hairs and many short spines. Anal ring with eight prominent hairs.

Hab. In Japan, on *Ficus carica* (Ichijiku), *Lagerstroemia indica* (Sarusuberi).

Type in the entmological collection of the Imperial Agricultural Experiment Station.

### Genus Gossyperia Sig.

#### 17. *Gossyparia ulmi* Geoff.

Coccus ulmi Linn., Faun Suec., p. 265 (1761).
,, ,, Geoff., Hist. Abr. Ins., i, p. 512 (1762).
,, spurius Mod., Act. Goth , i, p. 43 (1778).
,, laniger Gmel., Syst. Nat., Ed. xiii, p. 2221 (1789).
Chermes ulmi Latr., Hist Nat. des Fourmis, p. 330 (1802).
Nidularia lanigera Targ., Catalogue, p. 34 (1869).
Gossyperia ulmi Sig., Ann. Soc. Ent. France, (3), v, p. 21 (1875).
,, spuria Ckll., Pr. Ac. N. Sci., Ph., p. 268 (1899).
,, ulmi Kuw., Pr. Cal. Ac. Sci., iii, p. 52 (1902).
Hab. In Japan, on elm.

## Tribe Dactylopiini.

### Genus Dactylopius Costa.

#### 18. *Dactylopius comstockii* (Kuw.).

Dactylopius comstockii Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 52 (1902).
Hab. In Japan, on mulberry-tree and maple.

#### 19. *Dactylopius kraunhiae* (Kuw.).

Dactylopius kraunhiae Kuw., Pr. Cal. Ac. Sci., (3) iii, p. 55 (1902).
Hab. In Japan, on *Kraunhia floribunda* (Fuji).

20. *Dactylopius pini* (Kuw.)

Dactylopius pini Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 54 (1902).

Hab. In Japan, on pine.

21. *Dactylopius takae* N. Sp. (Pl. XXX, Figs. 34–38).

*Adult female:* Length about 6 mm., width 3 mm.; elliptical in form; pale yellowish green in color and covered with a white cottony secration.

Antennae are composed of eight segments; eighth segment the longest; second segment next to the longest; sixth segment the shortest; others subequal; formula; 8, 3, (1,2), 5, 4, 7, 6.; terminal segment bears many long hairs. Mouth parts small, but well formed; muntum composed of two segments, conical in form. Legs large and subequal; coxa longer than wide; trocanter triangular in form, bears one long hair; femur the longest, and bears many spiny hairs on the anterior margin; tibia a little shorter than femur, and bears many strong spiny hairs on both sides; tarsus about one half the length of tibia, tapering posterially; claw strong, curved. The posterior end of the body is furnished with two well chitinized lobes, each lobe bears a long hairs and many spines. Anal ring with six prominent hairs.

Hab. In Japan, on bamboo.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

22. *Dactylopius citri* (Risso).

Dorthesia citri Risso. Essai, Hist des Oranges (1893).

Coccus citri Bdv., Ent. Hort. p. 348 (1867).

Dactylopius citri Sign., Ann. oc. Ent. Fr., (5), v, p. 312 (1875).

Lecanium phyllococcus Ashm., Can. Ent., xi, p. 160, (1879).

Dactylopius brevispinus Targ., Annali di. Agr., p. 137 (1881).

„ destructor Comst., Rep. U. S. Dep. Ag. 1880, p. 342 (1881).

Hab. In Japan, on orange.

23. *Dactylopius longispinus* Targ.

Coccus adonidum corpore roseo, etc., Geoff., Abr. Ins., i, p. 511 (1762).
Pseudococcus „ Westw., Mod. Class. Ins., i, Synop, p. 118 (1839).
Coccus „ Blanch, Hist. Nat. Ins., iii, p. 213 (1840).
Dactylopius longispinus Targ., Catalogue, p. 32 (1869).
„ adonidum Sign., Ann., Soc. Ent. Fr., (5), v, p. 306 (1875).
„ pteridis Sign. „ „ „ „; „ p. 321 (1875).
„ adonidum Licht., Bull. „ „ „ „ vi. p. lxiv (1876).
„ longifilis Comst., Rep. U. S. Dep. Agr., 1880, p. 341 (1881).
Hab. In Japan, on orange, pear, and plum.

Genus Phenacoccus Ckll.

24. *Phenacoccus pargandei* (Ckll.).

Phenacoccus pergandei Ckll., Psyche, vii, Suppl., i, p. 18 (1896).
„ „ Ckll., Bull. A. T.S. Dep. Agr. U. S., p. 55 (1896).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 56 (1902).
Hab. In Japan, on *Diosypros kaki*, (*Kaki*), mulberry-tree etc.

Genus Sphaeracoccus Mask.

25. *Sphaeracoccus parvus* (Mask).

Sphaerococcus parvus Mask., E. M. M., xxxiii, p. 244 (1897).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 56 (1902).
Hab. In Japan, on cherry.

Genus Antonina Sign.

26. *Antonina crawi* (Ckll.).

Antonina crawi Ckll., Psyche, ix, p. 701 (1900).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 57 (1902).
Hab. In Japan, on bamboo.

## Genus Ripersia Sign.

### 27. *Ripersia japonica* N. Sp. (Pl. XXXI. Figs. 39–41).

♀ *Adult:*—Length 4 to 5 mm., width 2 to 2.5 mm.; long ovate in outline; dark purple in color; distinctly segmented, and thinly covered with a cottony secretion.

Boild in KOH, the color turned into reddish purple; dorsum has many small round pits. Antennae are composed of seven segments, although sometimes only six; usually the seventh segment is the longest, bears many long hairs; there is great variation in the proportional length of the antennal segments, which appears in the following formulae:

6, 2, (1, 3), 4, 5.
6, 1, (2, 3), 4. 5.
7, (2, 4), 6, 5, 3, 1.
7, (3, 4), 6, 5, 2, 1.
7, 1, 2, 4, 6, (3, 5).
7, 1, 2, 3, 4, (1, 6).
6, 1, (2, 3), 5, 7, 4.
7, (2, 1), 3, 5, 6, 4.
7, 2, 1, 2, 6, (4, 5).
7, (1, 2), 4, 6, 5, 3.

Mouth parts well formed, but small; rostral loop short. Legs subequal; femur long and longer than tarsus; tarsal digitules long with fine hairs, while these on the claw are short and stout; claw large, slightly curved. Anal ring has six prominent hairs.

Hab. In Japan, lives under sheathing base of leaf of *Miscanthus* (Kaya).

Type in the entomological collection of the Imperial Agricultural Experiment Station.

### 28. *Ripersia Oryzæ* N. Sp. (Pl. XXXI, Figs. 42–47).

♀ *Adult:*—Length about 2 mm., width about 1 mm.; oval in the outline; segmentation distinct; covered with white cottony secretion; pale yellow in color. Legs and antennae very short.

Antennae usually six segmented ; formulae :

2, 5, (1, 3, 4).
5, 2, 1, (3, 4).
6, (1, 2, 3), (4, 5).
6, 1, (2, 3, 4, 5).

Three pairs of legs are subequal, femur very long, almost as long as tibia and tarsus together ; tibia and tarsus usually about equal in length. Abdominal lobes very distinct and well chitinized ; each lobe bears many spiny hairs and a large hook-like appendage at the terminal end. Anal ring has six prominent hairs.

Hab. In Japan, found on the root of rice and other plants.

Type in the entomological collection of the Imp. Agr. Exp. Sta.

### Genus Aclerda Sign.

29. *Aclerda tokionis* (Ckll.).

Spheracocus (Pseudolecanium) tokionis Ckll., Psyche, vii, Supple., i, p. 19, (1896).

,, ,, ,, Ckll , Bull, 4, T.S., Dep. Ag. p. 49 (1896).

Pseudolecanium ., Ckll., Pr. Ac. N. Sci. Ph., p. 263 (1899).

,, ,, ,, Kuw., Pr. Cal. Ac. Sci., (3), ii, p. 403 (1901).

,, ,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 57, (1902).

Hab. In Japan, on bamboo.

30. *Aclerda(?) bivakoensis* N. Sp. (Pl. XXXI, Figs. 45–54).

♀ *Adult:*—Length 4,5 to 7 mm., width 2 to 3,5 mm.; Ellipsoidal in form ; pinkish brown in color, when dried, chestnut brown. The sides of the body nearly parallel, with two shallow invaginations on each side of the body ; anterior end of the body round, slightly narrower than the posterior ; slightly covered, with a white cottony secretion. Boild in KOH the body

becomes transparent, yellowish brown, with the margins golden brown. Mouth parts well chitinized, but rather small, and placed on the ventral aspect of the body, very near the middle. Antennae and legs are wanting. Many short captate spines on the dorsal aspect of the body. Posterior end of the body has no distinct cleft, but slightly inagenated.

Hab. In Japan, on *Rhragmites communis* (Yoshi). The female lines under the sheathing base of the plant.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

## Subfamily Lecaniinae.

### Genus Pulvinaria Targ.

#### 31. *Pulvinaria aurantii* (Ckll.)

Pulvinaria aurantii Ckll., Bull. 4, T.S. Dep. Ag. U. S., p. 48 (1896).
„ „ Ckll., Psyche, vii, Suppl., i, p. 19 (1896).
„ „ Ckll., Annali di Agr., p. 103 (1898).
„ „ Ckll., Pr. Ac. N. Sci. Ph., p 272 (1899).
„ „ Kuw , Pr. Cal. Ac. Sci., (3), iii, p. 58 (1992).

Hab. In Japan, on orange, tea plant, and others.

#### 32. *Pulvinaria psidii* (Mask.).

Pulvinaria psidii Mask., N. Z., Trans. xxv, p. 223 (1892).
„ „ How., Insect Life , vii, p. 426, (1895).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 58 (1902).

Hab. In Japan, on tea-plant, citrus, *Pittosporum tobira* (Tobera), *Eurya japonica* (sakaki) and others.

#### 33. *Pulvinaria kuwacola* N. Sp (Pl. XXXII, Figs. 55–58).

♀ *Adult:*—Length 6 to 8 mm., with 5 to 6 mm.; yellowish brown in color (dried specimen); suboval in form, with many transverse wrinkles on the dorsal aspect. Egg sac snow white, about 3 mm. long.

Antennae are composed of eight segments, third and fourth segments

subequal and the longest; many fine hairs on the terminal segment; formula: 3, 4, 2, 8, 1, 5, (6, 7). Legs stout and large; coxa is longer than wide, bears a few fine hairs; tibia almost three times as long as tarsus; claw is very strong slightly curved; digitules on tarsus have fine hairs, while that on the claw short and stout. Anal ring with six hairs. Triangular plates small.

Hab. In Japan, on mulberry.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

### 34. *Pulvinaria Oyamae* (Kuw.).

Pulvinaria Oyamae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 60 (1902).

Hab. In Japan, on willow.

### 35. *Pulvinaria horii* (Kuw.).

Pulvinaria horii Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 59 (1902).

Hab. In Japan, on *Acer trifidum* (To-kaede), *Aesculus turbinata* (To-chino-ki), and *Koelreuteria Paniculata* (Mokugenji).

### 36. *Pulvinaria hazae* (Kuw.).

Pulvinaria hazae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 59 (1902).

Hab. In Japan, on *Rhus succedanea* (Haze).

## Genus Takahashia Ckll.

### 37. *Takahashia japonica* (Ckll).

Pulvinaria (Takahashia) japonica Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

„ „ „ Ckll., Bull., 4, T.S., Dep. Ag., U. S., p. 49 (1896).

Takahashia japonica Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 61 (1902).

Hab. In Japan, on mulberry and others.

### Genus Ericerus Guirin.

38. *Ericerus pela* (Chav).

Coccus pe-la chav., Ann. Soc. Ent. Fr., (2), vi, p. 144, (1848).
„ „ Westw., Gard. Chron., pp. 484, 532 (1853).
Ericerus „ Guér., Bull. Soc. Ent. Fr., (3), vi, p. lxvii (1858).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 62 (1902).
„ „ Sasaki, Bull. Ag. College, Tokyo Imp. Univ., vol. vi, pp. 1–14 (1904).
Hab. In Japan, on *Ligustrum ibota* (Ibota-noki), *Fraxinus bungeana* (Toneriko).

### Genus Ceroplastes Gray.

39. *Ceroplastes ceriferus* (And.).

Coccus Ceriferus Anderson, Mon. Cocciceriferi (1791).
Ceroplastes chilensis Gray, Spicilegia Zoologica, p. 7 (1830).
„ „ Sign., Ann. Soc., Ent. Fr., (5), ii, p. 40 (1872).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 62 (1902).
Hab. In Japan, on *Taonabo japonica* (Mokkoku), *Rhus succedanea* (Haze) etc.

40. *Ceroplastes floridensis* (Comst.)

Ceroplastes floridensis Comst., Rep. U. S. Dep. Ag., 1880, p. 331(1881).
„ rusci Ashm. (Non. Linn.), Can. Ent., xii, p. 252 (1880).
„ floridensis Kuw., Pr. Cal. Sci., (3), iii, p. 62 (1902).
Hab. In Japan, on tea plant, oleander, orange, *Thea sasanqua* (Sazan-kwa), *Gardenia florida* (Kuchinashi), etc.

### Genus Lecanium Illig.

41. *Lecanium hemisphaericus* (Targ.).

Lecanium hemisphaericum Targ., Studii sul. Cocc., pp. 26, 27, 30, 39, 63, (1867).
„ Coffeae Sign. (non Walk.), Ann. Soc. Ent. Fr., (5), iii, p. 435, (1873).

Saissetia hemisphaerica Ckll., The Ent. Student, ii, p. 32 (1901).

Lecanium (Saissexia) ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 63, (1902).

Hab. In Japan, on *Phajus grandiflorus* (kwakuran), *Gardenia florida*, coffee, *Asparagus plumosus*, *etc.*

42. *Lecanium kunoensis* N. Sp. (Pl. XXXII, Fig. 59–66).

♀ *Adult:*—Diameter, about 5 mm. (the largest); globose, with many small pits shiny chestnut in color.

Antennae are composed of seven segments, third segment the longest, almost equal to found fifth, sixth and seventh segment together. Legs subequal; femur and tibia subequal in length; tarsus less than one half of the length of tibia; claw short stout. Anal plate small.

Hab. In Japan, on *Rhamnus japonicus* (Kuro-ume-modoki), *Prunus mume* (ume), *Pirus sinensis* (Nashi) etc.

Type in the entmological collection of the Imp. Agr. Exp. Sta.

43. *Lecanium glandi* N. Sp. (Pl. XXXIII. Figs. 67–74).

♀ *Adult:*—Length about 15 mm. (the largest), width about 12 mm., hight about 10 mm.; subglobose in form; derm apparently thick; shiny chestnut brown in color, with many small shallow depressions; sloping posteriorly; and anal cleft very deep. Antennae are composed of eight segments; third segment the longest; others subequal. Legs rather short and weak; tarsus much shorter than tibia, claw stout and slightly curved anal plates normal.

Hab. In Japan, on apple, pear and other trees.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

44. *Lecanium takachihoi* (Kuw.).

Lecanium (Eulecanium) takachihoi Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 63 (1902).

Hab. In Japan, on chestnut.

45. *Lecanium oleae* (Bern.).

Chermer oleae Bern:, Mem. d'Hist. Nat. Acad., Marseille, p. 108 (1782).
Coccus oleae Oliv., Ency. Meth., vi, p. 95 (1791).
Lecanium oleae Walk., Cat. Br. Mus., Hom., p. 1070 (1852).
Saissetia oleae Ckll., The Ent. Student, ii, p. 31 (1901).
Lecanium (Saiesetia) oleae Kuw., Pr. Cal. Ac. Sci., (3), iii; p. 64 (1902).
Hab. In Japan, on *citrus*.

46. *Lecanium hesperidum* (L.).

Coccus hesperidum Linn., Syst. Nat., Ed. x, i, p. 455 (1758).
Chermes „ Geoff., Abr. Ins., i, p. 505 (1762).
Calypticus „ Costa, Faun, Reg. Nap., Cocc., p. 8 (1835).
Calymmatus „ Costa, Nuov. Osserve., p. 22 (1835).
Lecanium „ Burm., Handb. Ent., ii, p. 69 (1835).
„ „ Kuw., Pr. Cal. Ac. Sci., (3). iii, p. 64, (1902).
Hab. In Japan, on *Abutilon* sp., *Nerium odorum* (Kyochikuto), *Jasminum* sp., *Cycas revoluta* (Sotetsu), *Eriobotrya japonica* (Biwa), *Cercis chinensis* (Hana-zuo), *Aegle sepiaria*.

47. *Lecanium nishigaharae* N. Sp. (Pl. XXXIII, Figs. 75–81).

♀ *Adult:*—Length 7 mm., width 6 mm., hight 3 mm.; nearly hemispherical in form, with many transverse wrinkles and one or more longitudinal ridges on dorsum. Antennae are composed of eight segments; third segment the longest; formula; 3, 4, 2, 1, 8, 5, 6, 7. Legs subequal, well developed; tibia very much longer than tarsus. Anal plates usual.

*First larval stage:*—Length 855 $\mu$., width 475 $\mu$.; oval in form. Antennae have seven segments; third segment the longest; formula: 3, 7, 2, 1, 4, 5, 6.

Hab. In Japan, on mulberry tree.

This species is very closely allied to *Lecanium mori* sign., but the following characteristics distinguish these two species:

| Lecanium mori sign. | Lecanium nishigaharae. |
|---|---|
| 1. Antennae are composed of 7 segments. | 1. Antennae are composed of 8 segments. |
| 2. Tibia and tarsus are subequal. | 2. Tibia is very much longer than tarsus. |
| 3. Larval antennae are composed of 6 segments. | 3. Larval antennae are composed of 7 segments. |

Hab. In Japan, on mulberry.

Type in the entmological collection of the Imperial Agricultural Experiment Station.

48. *Lecanium frontale* (Green).

Lecanium frontale Green, Coccidae of Cylon, vol. iii, p. 192 (1904).

Hab. In Japan, on Palm.

49. *Lecanium tessellatum* (Sign).

Lecanium tessellatum sign., Ann. Soc. Ent. Fr., (5), iii, p. 401 (1873).

Coccus „ Kirkaldy, Faun. Haw., iii, pl. 2, p. 106 (1902).

Eucalymnatus „ Ckll., Ann. Mag. N.H., (7), ix, p. 453.

Hab. In Japan, on Palm.

## Subfamily Diaspinae.

### Genus Aspidiotus Bouche.

50. *Aspidiotus inucitata* (Green).

Aspidiotus inucitatus Green, Coccidae of Ceylon, Part I, p. 65 (1902).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 65, (1902).

Hab. In Japan, on bamboo.

51. *Aspidiotus secrcta* (Ckll.).

Aspidiotus secretus Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

„ „ Ckll., Bull. 4., T. S., Dep. Agr. U. S., p. 51, (1896).

„ (Odonaspis) „ Ckll., Bull. 6, T. S., Dep. Agr. U. S., p. 14, 20. 31, (1897).

Spatheaspis secretus Leon., Riv. Pat. Veg., vi, p. 115 (1897).

Hab. In Japan, on bamboo.

52. *Aspidiotus secreta, var lobulatus* (Mask.).

Aspidiotus secretus, var lobulatus Mask., Ent. Mon. Mag., xxxiii, p. 24, (1897).

„ „ „ „ Mask., New Zealand Tran. xxx, p. 224 (1898).

Spatheaspis „ „ „ Leon., Gen. e Spec. Diaspiti, Asp., p. 221.

Hab. In Japan, on bamboo.

53. *Aspidiotus trilobiformis* (Green).

Aspidiotus trilobiformis Green, In. Mus. Notes vol. iv, p. 4 (1896).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 66 (1902).

Hab. In Japan, on ?

54. *Aspidiotus duplex* (Ckll.)

Aspidiotus duplex Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

„ „ „ Bull. 4, T. S., U. S., Dep. Agr., p. 52 (1896).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 66 (1902).

Hab. In Japan, on *Rhus succidanea*, *Eurya ochnacea*, *Thea japonica*, *Aegle sepiaria*.

55. *Aspidiotus paeoniae* (Ckll.).

Aspidiotus duplex, var. Paeoniae Ckll., Can. Ent. xxxi, p. 105 (1899).

„ „ „ „ Kuw., Pr. Cal. Ac. Sci., (3) iii, p. 66, (1902).

Hab. In Japan, on *Eurya ochnacea*, *Thea chinensis*, *Rhododendron indicum* var. *Kaempferi* (Tsutsuji), R. *indicum* var. *Macranthum* (satsuki), *Ilex latifolia* (Taraya), *Clethra barbinervis* (Ryobu), *Thea japonica*, *Paeonia moutan* (Botan), etc.

56. *Aspidiotus perniciosus* (Comst.).

Aspidiotus perniciosus Comst., Rep. U. S., Dep. Agr. 1880, p. 304(1881).
„ „ var. albopunctatus Ckll., Psyche, vii, Suppl., i. p. 20 (1896).
„ „ var andromelas Ckll., Bull. 6, T. S., Dep. Ag. U.S. p. 224 (1900).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 67 (1902).
„ „ Kuw., San Jose Scale in Japan (1901, 1904).
Hab. In Japan, on pear, apple, peach, Japanese quence, currant, willow, *Pæonia moutan, citrus* etc.

57. *Aspidiotus rapax* (Comst.).

Aspidiotus camelliae Sign. (Non Bdv.), Ann. Soc. Ent. Fr., (4), ix, p. 117 (1869).
„ convexus Comst., Rep. U. S., Dep. Ag., 1880, p. 285 (1881).
„ rapax Comst., Rep. U. S., Dep. Ag., 1880, p. 307 (1881).
Hab. In Japan, on fruit tree from America.

58. *Aspidiotus ulmi* (John.).

Aspidiotus ulmi John., Bull. Ill., State Lab. N. Hist., iv, p. 388 (1896).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 68 (1902).
Hab. In Japan, on elm.

59. *Aspidiotus cyanophylli* (Sign).

Aspidiotus cyanophylli Sign., Ann. Soc., Ent. Fr., (4), ix, p. 119 (1869).
Hab. In Japan, on palm in green house.

60. *Aspidiotus lataniæ* (Sign.).

Aspidiotus lataniae Sign., Ann. Soc. Ent. Fr., (4), ix, p. 124 (1869).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 68 (1902).
Hab. In Japan, on tea plant.

61. *Aspidiotus cryptomeriæ* (Kuw.).

Aspidiotus cryptomeriæ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 69, (1902).
Hab. In Japan, on *Cryptomeria japonica* (Sugi).

62. *Aspidiotus jordani* (Kuw.).

Aspidiotus jordani Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 69 (1902).

Hab. In Japan, on oak.

63. *Aspidiotus aurantii* (Mask.).

Aspidiotus aurantii Mask., N. Z. Trans., xi, p. 199 (1878).
Chrysomphalus „ Ckll., Check List. Suppl., p. 396 (1899).
Aspidiotus (chrysomphalus) „ Kuw., Pr. Cal. Ac. Sci., (3), iii, P. 70, (1902).
Hab. In Japan, on *Podocarpus chinensis*, *Acacia*, orange and tea plant.

62. *Aspidiotus ficus* (Ashm.).

Coccus aonidum Linn., Syst. Nat., El. x, i, p. 455 (1758).
Chrysomphalus ficus Ashm., Am. Ent., iii, p. 267 (1880).
Aspidiotus ficus Comst., Rep. U. S., Dep. Ag., 1880, p. 296 (1881).
„ (Chrysomphalus) ficus Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 71 (1902).
Hab. In Japan, on *Asparagus plumasus*, *Machilus Thunbergii* (Inugusu, Tabu-no-ki), mango, *Aspidistra lurida* (Baran), *Ligustrum japonicum* (Nezumimochi).

65. *Aspidiotus kelloggi* (Kuw.).

Aspidiotus kelloggi Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 71 (1002).
Hab. In Japan, on ?

66. *Aspidiotus bambusarum* (Ckll.).

Aspidiotus (Odonaspis) bambusarum Ckll., Psyche, viii, p. 191 (1898).

Hab. In Japan, on bamboo.

## Genus Diaspis Costa.

### 67. *Diaspis pentagona* (Targ.).

Diaspis pentagona Targ., Revista di Bacchicoltura, No. 11 (1885).
„ amygidali Tryon, Rep. on Fungous Pesla, p. 89 (1889).
„ lanatus Morg. and Ckll., Journ. Inst. Jam., i, p. 137 (1892).
? Chionaspis prunicola Mask., N. Z. Trans., xxvii, p. 49 (1894).
Diaspis patelliformis Sasaki, Bull. Ag. Coll., Tokyo, p. 107 (1894).
„ pentagona Kuw., Pr. Cal. Ac. Sci., (3), iii. p. 72 (1902).
Hab. In Japan, on cherry, plum, prune, peach, walnut, grape, mulberry, persimmon, geranium, etc.

### 68. *Diaspis Crawi* (Ckll.).

Diaspis Crawi Ckll., Psyche, viii, p. 190 (1898).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 73 (1902).
Hab. In Japan, on *gumi*.

### 69. *Diaspis rosae* (Bouchè).

Aspidiotus rosae Bouchè, Naturg. Ins., p. 14 (1834).
Diaspis rosae Sign., Ann. Soc. Ent. Fr., (4), ix, p. 441 (1869).
Aulcaspis rosae Ckll., Bull. Bot. Dep. Jam., p. 259 (1896).
„ „ Kuw., Pr. Cal. Ac., Sci., (3), iii, p. 73 (1902).
Hab. In Japan, on rose, *Rubus morifolius* (Kumaichigo).

### 70. *Diaspis rosae var. spinosa* (Mask.).

Aulacaspis rosae var. spinosa Mask., Ent. Mon. Mag., xxxiii, p. 241, (1897).

Hab. In Japan, on smilax.

## Genus Leucaspis Targ.

### 11. *Leucaspis japonica* (Ckll.).

Leucaspis japonica Ckll., Psyche, viii, p. 53 (1897).

Leucaspis japonica Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 741 (1902).
Hab. In Japan, on apple, pear, orange, persimmmon, etc.

*72. Leucaspis bambusae* (Kuw.).

Leucaspis bambusae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 74 (1902).
Hab. In Japan, on bamboo.

Genus Chionaspis Sign.

*73. Chionaspis aspidistrae* (Sign).

Chionaspis aspidistrae Sign., Ann. Soc. Ent. Fr., (4), ix, p. 443 (1869).
Hemichionaspis „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 75 (1902).
Hab. In Japan, on *Aspidistra lurida*, ochids, orange etc.

*74. Chionaspis euonymi* (Comst.).

Chionaspis euonymi Comst., Rep. U. S. Dep. Agr., 1880, p. 313 (1881).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 75 (1902).
Hab. In Japan, on *Euonymus japonica* (Masaki).

*75. Chionaspis hikosani* (Kuw.).

Chionaspis hikosani Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 76 (1902).
Hab. In Japan, on bamboo.

*76. Chionaspis bambusae* (Ckll.).

Chionaspis bambusae Ckll., Psyche, vii, Supple., i, p. 21 (1896).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 76 (1902).
Hab. In Japan, on bamboo.

*77. Chionaspis platani* (Cooley).

Chionaspis platani Cooley, Spec. Bull. Mass. Exp. Sta., p. 36 (1899).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).
Hab. In Japan, on *Rhus sp.*

*78. Chionaspis wistariae* (Cooley).

Chionaspis wistariae Cooley, Can. Ent., xxix, p. 280 (1897).

Chionaspis wistariae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).
Hab. In Japan, on wistaria (Fuji).

79. *Chionaspis colemani* (Kuw.).

Chionaspis colemani Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).
Hab. In Japan, on bamboo.

80. *Chionaspis citri* (Comst.).

Chionaspis euonymi Comst., Rep. U. S. Dep. Ag., 1880, p. 313 (1881).
„ citri Comst., 2nd Rep. Ent. Corn. Univ., p. 100 (1883).
Hab. In Japan, on *citrus*.

Genus Parlatoria Targ.

81. *Parlatoria proteus* (Curt.).

Aspidiotus proteus Curt., Gard. Chron., p. 676 (1843).
Daiaspis parlatoris Targ., Studii Sul. Cocc., p. 14 (1867).
(?) Parlatoria orbicularis Targ., Catalogue, p. 42 (1869).
Parlatoria proteus Sign., Ann. Soc. Ent. Fr., (4), ix, p. 450 (1869).
(?) Aspidiotus targionii Del. guer., 11, Naturalista Siciliano, No. 8 (1894).
Parlatoria proteus Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).
Hab. In Japan, on *Angraecum falcatum* (Furan), *Viburum odoratissimum* (sango-ju), *Thea sasanqua* (sazankwa), pear, apple, etc.

82. *Parlatoria pergandii* (Comst.).

Parlatoria pergandii Comst, Rep. U. S. Dep. Ag., 1880, p. 327 (1881).
„ „ Craw, Rep. Cal. Sta. Bd. Hort., 1897–98, p. 98.
„ „ Kuw, Pr. Cal. Ac. Sci., (3), iii, p. 78 (1902).
Hab. In Japan, on orange, pear, etc.

83. *Parlatoria theae* Ckll.

Parlatoria theae Ckll., Psyche, vii, Suppl., i, p. 21 (1896).
„ „ Ckll., Bull. 4, T.s., Dep. Ag. U. S. A., p. 55 (1856).

Parlatoria pergandii var. theae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 78 (1902).

Hab. In Japan, on *Acer crataegifolium* (Uri-kaede), *A pictum*, (Itaya-kaede), *Diospyros Kaki* (Kaki), rose, *Cornus macrophylla* (Mizuki), *Osmanthus fragrans* (Mokusei) etc.

84. *Parlatoria ziziphus* (Lucas).

Coccus ziziphus Lucas., Bull., Soc. Ent. Fr., (3), i, xxviii (1853).

Chermes aurantii Bdv., Ent. Hort., p. 338 (1867).

Parlatoria lucasii Targ., Catalogue, p. 52 (1869).

„ ziziphus Sig., Ann. Soc., Ent. Fr., (4). ix, p. 451 (1869).

„ lucasii Targ., Annani di Agr., p. 398 (1884).

Hab. In Japan on orange.

Genus Fiorinia Targ.

85. *Fiorinia fioriniae* (Targ.).

Diaspis fioriniae Targ., Studii Sul. Cocc., p. 14 (1867).

Chermes arecae Bdv., Insectologie Agricole, p. 262 (1868).

Fiorinia pellucida Targ., Catalogue, p. 42 (1869).

„ camelliae Comst., Rep. U. S. Dep. Ag., 1880, p. 329 (1881).

Uhleria fioriniae Comst., 2nd. Rep. Dep. Ent. Corn. Univ.,p. 111 (1881).

„ camelliae Comst , „ „ „ „ „ „ „ „ „

Fiorinia fioriniae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).

Hab. In Japan, on fern, *Theæ japonica* etc.

86. *Fiorinia fiorinae*, var. *japonica* (Kuw.).

Fiorinia fioriniae var. japonica Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).

Hab. In Japan, on *Podocarpus chinensis* (Maki), Pine.

Genus Mytilaspis Sign.

87. *Mytilaspis pomorum* (Bauche).

Coccus ulmi Linn., Syst. Nat., Ed., x, i, p. 455 (1758).

Chermes arborum, linearis geoff., Abr. Ins., i, p. 509 (1762).
Coccus linearis Mod., Act. Goth., i, p. 22 (1778).
„ conchiformis Gmel., Syst. Nat., Ed. xiii, p. 222 (1789).
Diaspis linearis Costa, Fann. Reg. Nap., Cocc., p. 21 (1835).
Aspidiotus conchiformis Curt., Gord. Chron., p. 375 (1843).
Mytilaspis falciformii Baer., D'Alton, zeit. für Zool., p. 168 (1849).
Lepidosaphes conchiformis Shimer, Tr. A.M. Ent. Soci., i, p. 373 (1868).
Aspidiotus pomarum Bouchi, Stett. Ent. Zeit., xii, p. 110 (1851).
Mytilaspis pomarum Sign., Ann. Soc. Eut. Fr., (4), x, p. 98 (1870).
„ „ Kuw., Pr. Cal. Ac. Sci., (3), ili, p. 80 (1902).
Hab. In Japan, on *Mespilus cuncata* (Sanzashi), *Ilex crenata* (Inutsuge), currant, apple.

88. *Mytilaspis pomorum var. japonica* (Kuw.).

Mytilaspis pomorum var. japonica Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 80 (1902).
Hab. In Japan, on *Abies firma* (Momi).

89. *Mytilaspis gloverii* (Pack).

Coccus gloverii Pack., Guide to Study of Insects., Ed. i. p. 527 (1869).
Aspidiotus gloverii Pack., 7th Rep. Mass. Bd. Ag., 1869, p. 259 (1870).
Mytilaspis gloverii Comst., Rep. U. S. Dep. Ag., 1876. p. 41 (1877).
„ „ Kuw, Pr. Cal. Ac. Sci., (3), iii, P. 81 (1902).
Hab. In Japan, on orange.

91. *Mytilaspis pallida* (Green).

Mytilaspis pallida Green, Ind. Mus. Notes, iv, p. 5 (1896).
„ gloverii var. pallida green ; Cocc. Ceylon, pt. i, p. 85. (1896).
Lepidosaphes pallida Kirkaldy, Fauna Haw., iii, pt. 2, p. iii (1902).
Hab. In Japan on *podocarpus sp, citrus.*

92. *Mytilaspis beckii* (Newm).

Coccus beckii Newm., The Ent., iv, p. 217, (1869).
Aspidiotus citriocola Pack., Guide to study of Insects, p. 527 (1869).

Coccus anguinus Bdv., Insectologie Agricole, iv (1870).

Mytilaspis fulva. Targ., Bull. Soc. Ent. Ital., p. 131 (1872).

„ flavescens Targ., Annali. R. Minist. Agr., p. 84 (1876).

„ citricola comst., Rep. U.S. Dep. Ag., 1880, p. 321 (1881).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii. P. 81 (1902).

Hab. In Japan, on *citrus*.

93. *Mytilaspis newsteadi* (Sulc).

Mytilaspis newsteadi Sulc, Sitzb. K. Bhom. Ges. Wiss., No. xlix, pp. 8,19 (1895).

„ „ Kuw., Pr. Cal, Ac. Sci., (3), iii, p, 82 (1902).

Hav. In Japan, on *Thcae japonica*.

94. *Mytilaspis newsteadi* var. *tokionis* (Kuw).

Mytilaspie newsteadi var. tokionis Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 81 (1902).

Hab. In Japan, on *Cadiaeum*.

95. *Mystilapis crawi* (Ckll).

Mytilaspis crawi Ckll., Psyche, vii, supl., i,p. 21 (1896).

Mytilaspis crawi Ckll., Bull. 4. T.S., Dep. Ag, S., P. 44 (1896).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, P. 82 (1902).

Hab. On Japan, on oak.

Genus Poliaspis Sign.

96. *Poliaspis pini* (Mask.)

Poliaspis pini Mask., E. M. M., xxxiii, p. 242 (1897).

„ „ „ ., N.Z. Trans., XXX, p. 231 (1898).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 82 (1902).

Hab. In Japan, on pine.

Genus Ischnaspis (Doug).

97. *Ischnaspis longirostria* (Sign).

Mytilaspis longirostria Sign., Bull. Soc. E. Fr., (6), ii, p. 25 (1882).

Ischnaspis filiformis Dougl., E. M. M., vol. xxiv, 1897.

Hab. In Japan, on palm.

## List of coccidae Recorded in Japan, not Included in the Foregoing List.

1. Dactylopius syringae Mask.
2. „ edgeworthiae Ckll.
3. „ virgatus Ckll.
4. Sphaerococcus populi Mask.
5. Asterolecanium delicata Green.
6. Lecanium notatum Mask.
7. „ cerasorum Ckll.
8. Ceronema japonica Mask.
9. Aspidiotus cryptoxanthus Ckll.
10. „ setiger Mask.
11. „ aurantii var. citrinus Coqu.
12. Diaspis auranticolar Ckll.
13. Aonidia elaeagnus Mask.
14. Chionaspis chinensis Ckll.
15. „ engeniae Mask.
16. „ aucubae Codey.
17. „ difficilis Ckll.
18. „ graminis Green.
19. „ vitis Green.
20. „ latissima Ckll.
21. „ citri Comst.
22. Fiorinia signata Mask.
23. „ tenuis Mask.
24. Mytilaspis machili Mask.
25. „ crawi var. canaliculata Mask.
26. „ pallida var. maskelii Ckll.
27. Parlatoria theae var. viridis Ckll.
28. „ „ „ euonymi Ckll.
29. „ proteus virescens Mask.

# EXPLANATION OF PLATES.

## Plate XXVIII.

### Icerya Okadae.

| | | | |
|---|---|---|---|
| Fig. | 1. | Female with host (Latral aspect). | ×2 |
| „ | 2. | „ (Dorsal aspect). | ×6 |
| „ | 3. | Antennae of female. | Z. 3×AA. |
| „ | 4. | Leg of female. | Z. 2×AA. |
| „ | 5. | Spiny hairs and round pits of dorsal aspect of female. | Z. 3×AA. |
| „ | 6. | „ | Z. 1×E. |
| „ | 7. | Pit of dorsal aspect of female. | Z. 3×E. |
| „ | 8. | First larval stage. | Z. 3×AA. |
| „ | 9. | Antennae of first larval stage. | Z. 3×C. |
| „ | 10. | Leg of the same. | |

## Plate XXIX.

### Cerococcus muratae.

| | | | |
|---|---|---|---|
| Fig. | 11. | Scales on host. | Natural size. |
| „ | 12. | Scale | ×5 |
| „ | 13. | Posterior end of the body of female. | Z. 1×E. |
| „ | 14. | Antennae of female. | Z. 3×E. |
| „ | 15. | Larva. | Z. 3×AA. |
| „ | 16. | Antennae of larva. | Z. 1×E. |
| „ | 17. | Leg of larva. | Z. 1×E. |

### Karmes vastus.

| | | | |
|---|---|---|---|
| Fig. | 18. | Adult female. | Natural size. |
| „ | 19. | „ | ×5 |
| „ | 20. | Antennae of the same. | Z. 1×E. |
| „ | 21. | Leg of the same. | Z. 1×E. |

## Kermes miyasakii.

Fig. 22. Adult females on host. Natural size.
„ 23. Female.
„ 24. Antennae of the same. Z. 1 × E.
„ 25. Leg of the same. Z. 1 × E.
„ 26. Antennae of larva. Z. 1 × E.
„ 27. Leg of the same. Z. 1 × E.
„ 28. Abdominal end of the same. Z. 3 × E.

PLATE. XXX.

## Eriococcus lagerstroemiae.

Fig. 29. Females on host. Natural size.
„ 30. Antennae of female. Z. 1 × C.
„ 31. Leg of the same. Z. 1 × C.
„ 32. Abdomiral end of the same. Z. 1 × C.
„ 33. Dorsal spines of the same. Z. 3 × C.

## Dactylopius takae.

Fig. 34. Females with host. Natural size.
„ 35. Female. Enlarged.
„ 36. Antennae of the same, Z. 1 × C.
„ 37. Leg of the same. Z. 3 × AA.
„ 37 a. Tarsal segment. Z. 3 × C.
„ 38. Abdominal end of female. Z. 3 × C.

PLATE. XXXI.

## Ripersia Japonica.

Fig. 39. Antennae of adult female.
„ 40. Leg of the same.
„ 41. Last abdominal segment of the same.

## Ripersia oryzae.

| | | | |
|---|---|---|---|
| Fig. | 42. | Females with rice stab. | Natural size. |
| „ | 43. | Female with youngs. | Enlarged. |
| „ | 44. | Female | Z. I × AA. |
| „ | 45. | Abdominal end of the same. | Z. I × E. |
| „ | 46. | Antennae of the same. | Z. I × E. |
| „ | 47. | Leg of the same. | Z. I × E. |

## Aclerda biwakoensis.

| | | | |
|---|---|---|---|
| Fig. | 48. | Females with host. | Natural size. |
| „ | 49. | Female | × 15 |
| „ | 50. | Abdominal end of the same. | Enlarged. |
| „ | 51. | „ | „ |
| „ | 52. | Spines of lateral aspect of the abdominal end. | Z. 4 × D. |
| „ | 53. | Spines of lateral aspect of the body. | Z. 4 × D. |
| „ | 54. | Marking of dorsal aspect of the female. | Z. 4 × D. |

PLATE. XXXII.

## Pulvinaria kuwacola.

| | | | |
|---|---|---|---|
| Fig. | 55. | Females on host. | Natural size. |
| „ | 56. | Spines at the lateral incision. | Z. I × C. |
| „ | 57. | Antennae of female. | Z. I × C. |
| „ | 58. | Leg of the same. | Z. I × C. |

## Lecanium Kunoensis.

| | | | |
|---|---|---|---|
| Fig. | 59. | Females on host. | about × 2 |
| „ | 60. | „ | Natural size. |
| „ | 61. | Antennae of female. | Z. I × E. |
| „ | 62. | Leg of the same. | Z. I × E. |
| „ | 63. | Lateral spines of female. | Z. I × E. |
| „ | 64. | Triangular plate of the same. | Z. I × E. |

Fig. 65. Marking of dorsal aspect of female. Z. 1 × E.
„ 66. Marking of ventral aspect of female. Z. 1 × E.

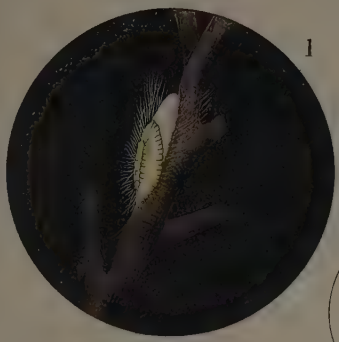
PLATE. XXXIII.

## Lecanium glandi.

Fig. 67. Adult female. Natural size.
„ 68. The same. × 5
„ 69. Antennae of the same. Z 2 × C.
„ 70. Leg of the same. Z. 4 × AA.
„ 70. a Tarsus of the same. Z. 4 × E.
„ 71. Spines of marginal incision. Z. 4 × E.
„ 72. Spines of abdominal end of the body of female. Z. 3 × AA.
„ 73. Marking of skin of female. Z. 1 × E.
„ 74. Triangular plates of female. Enlarged.

## Lecanium nishigaharae.

Fig. 75. Females on host. Natural size.
„ 76. Female. × 5
„ 77. Antennae of the same. Z. 1 × C.
„ 78. Leg of the same. Z. 1 × C.
„ 79. Spines of marginal incision. Z. 1 × C.
„ 80. Triangular plates of female. Z. 1 × C.
„ 81. Marking of skin of female. Z. 2 × C.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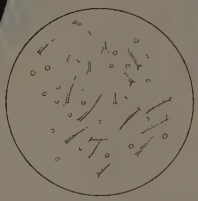
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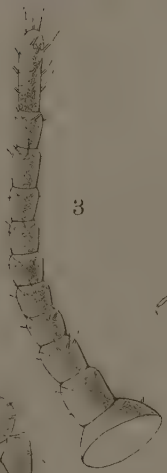
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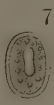
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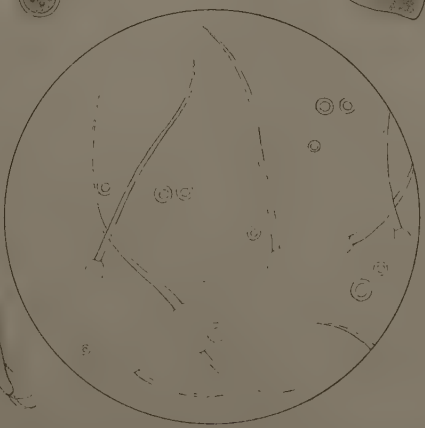
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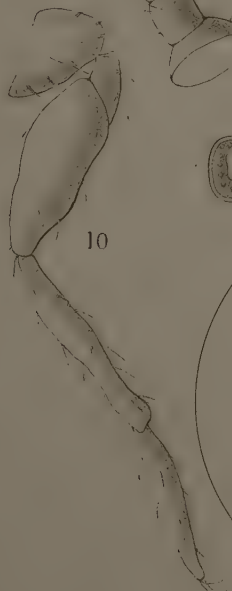
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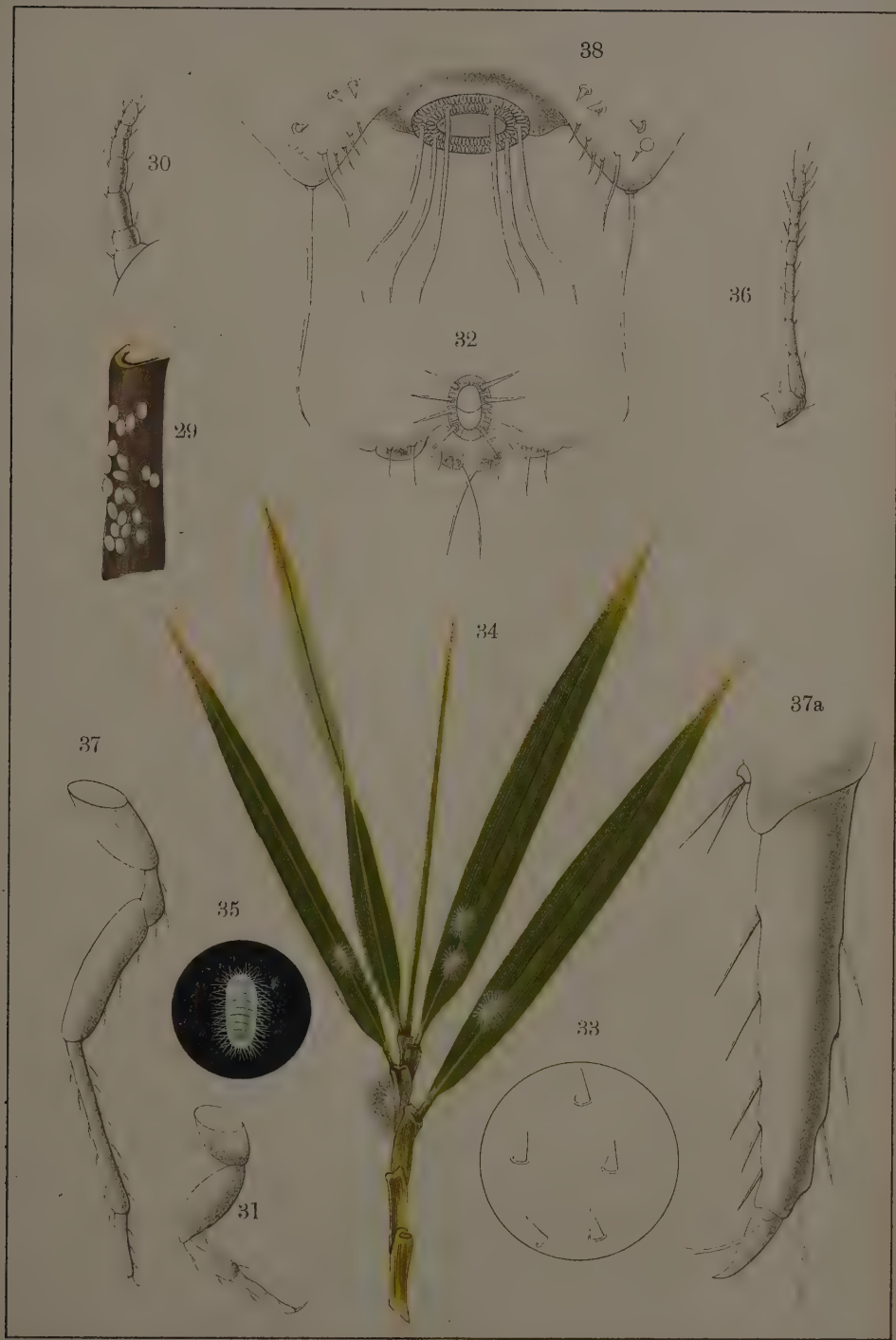


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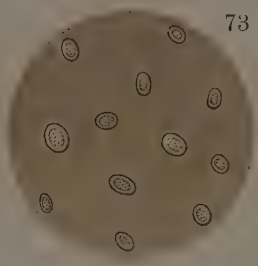
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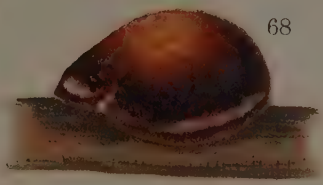
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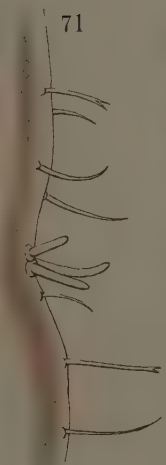
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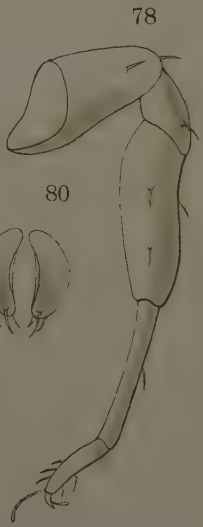
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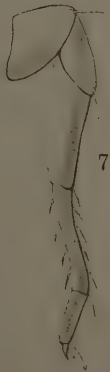
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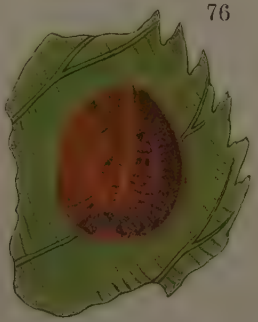
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## Coccidæ of Japan, II.

# A New Xylococcus in Japan.

BY

S. I. Kuwana.

XYLOCOCCUS MATSUMURAE N. sp.

(Plate XXXIV, Figs. 1—13.)

*Egg:*—Length 133 $\mu$., width 153 $\mu$., regularly oval in outline; shiny and of light arange color with two black spots near the anterior extremity.

*Newly hatched larva:*—Length 189 $\mu$., width 117 $\mu$., across broadest part of the abdomen. Elliptical in form, slightly narrower anteriorly; the posterior end of the abdomen broadly round; segmentation distinct. Color light yellowish orange, the eyes dark purplish and very prominent. Antennae and legs very large, well formed.

*Antennae:* Comparatively large, composed of seven segments; length about 91 $\mu$.; segment 1 stoutest and broadest; segment 2 longest, but only slightly longer than 4 or 6; segment 5 shortest, and segment 3 and 7 subequal to 5; segments 6 and 7 bear a few fine hairs.

*Leg:* Well developed; femur very large; tibia longer than tarsus; claw strong, slightly curved; digitules of tarsus long and fine hairs, longer than that of claw.

*Mouth parts:* Very large, well chitinized; rostrum large, two segments; rostral loop very long.

*Abdomen:* Composed of nine segments; last segment bears two long and two short spiny hairs.

*Adult female:*—Length, about 4.5 mm., width about 2 mm. Elliptical in form, with anterior end slightly narrow, very prompt, distinctly seg-

mented. Color when living reddish brown; antennae and legs light brown. Antennae and legs are well developed but mouth parts are wanting.

*Antenna:* Length about 1 mm.; composed of 10 segments; segment 1 longest and broadest; next in length is 3, and then 2; segments 8,9 and 10 subequal and shortest; formula; 1, 3, 2, 4, (5, 6, 7), (8, 9, 10); each segment bears a few spiny hairs.

*Leg:* Large and stout; three pairs alike; trochanter usual triangular in form, bears a long spiny hair; femur slightly longer than tibia; tibia much longer than tarsus; tarsal segment bears scalely marking as shown in the figure, a few spiny hairs on the inner margin; claw short and stout, slightly curved; tarsal digitules long, fine hairs, those of claw short and stout.

Abdominal end without hair; anal tube indistinct. The body is covered with many minute hairs, and many small round pores are scattered all over the surface of the body.

Quite active, but when ready to deposit eggs, crawls into some crevice or crack of bark and produces a cottony cushion on which the female rests and secretes a considerable amount of white cottony substance over its entire body.

*Adult male:*—Length about 2 mm., length of wings 1.5 mm., width of thorax about 1 mm. Abdomen brownish orange in color, thorax black, front of head dark, eyes dusky.

*Eye:* Large, prominent, facetted.

*Antennae:* Length about 2 mm.; slender; hairy; Composed of 9 segments; segment 1 shortest and stoutest, other segments subegual and deeply incised between segments; each segment bears a few fine hairs, while the last segment bears four prominent knobed hairs.

*Leg:* Three pairs of legs are subequal, slender, hairy; tibia more than three times as long as tarsus; tarsus bears scalely marking, bears many strong spines in the inner margin; claw short and stout, slightly curved; digitules normal.

*Wing:* Cinereous, the costal space fuliginous, the veins blackish brown, a streak near the descoidal vein in front and a narrow oblique streak behind the vein, colorless. The surface of wing irregularly reticulated.

*Haltere :* Large, club-shaped; bearing fine stout hooks at the apex which are curved and enlarged at the tip.

*Abdomen :* Spindle in shape; style short, but comparatively stout, slightly curved; sexual organ very large. On the dorsal aspect of eighth segment there is a large hump on which are ten prominent tubes through which a white, silverly, waxy substance is secreted, which forms long threads, exceeding the abdomen in length.

*Habitat :*—The writer collected this species on the bark of trunk of pine-tree (matsu), at Sugamo, Tokyo, Japan, on May 20th 1903.

This new species of Xylococcus was carefully compared by the writer with other known species, but the shape of antennae of newly hatched larva and that of female are quite different from any of them. The shape of style of male is also remarkably different from the known species, hence the writer feels justified describing this Japanese insect as a new species.

Type in the entomological collection of the Imp. Agr. Exp. Sta.

Three species of the genus Xylococcus have been heretofore known, as they are recorded as coming from the following localities:

1. Xylococcus betulae Perg.
   Lake Surperior, U. S. A. on birch.
2. Xylococcus feliferus Loew.
   Australia. on Tilia earopoea.
   T. grandifolia.
3. Xylococcus quercus Ehrh.
   California, U. S. A. on Quercus chrysalepis.

*Biblography of the Genus Xylococcus.*

Xylococcus betulae Perg.

1898. Pergande,—Bul. 18, N.S., U.S. Dept. Agr., PP. 18–19.

Xylococcus filiferus Leow.

1882. Leow,—Verh, z. b. Ges. Wien, pp. 271–274.

1882. Sign.—Bul, Soc. Ent. Fr., (6). ii, p. CLXXV.

1890. Maskell,—Ent. Mon. Mag., XXVI, P. 278.

1898. Hubbard,—Bul, 18, N.S., U.S. Dept. Ag., P. 17.

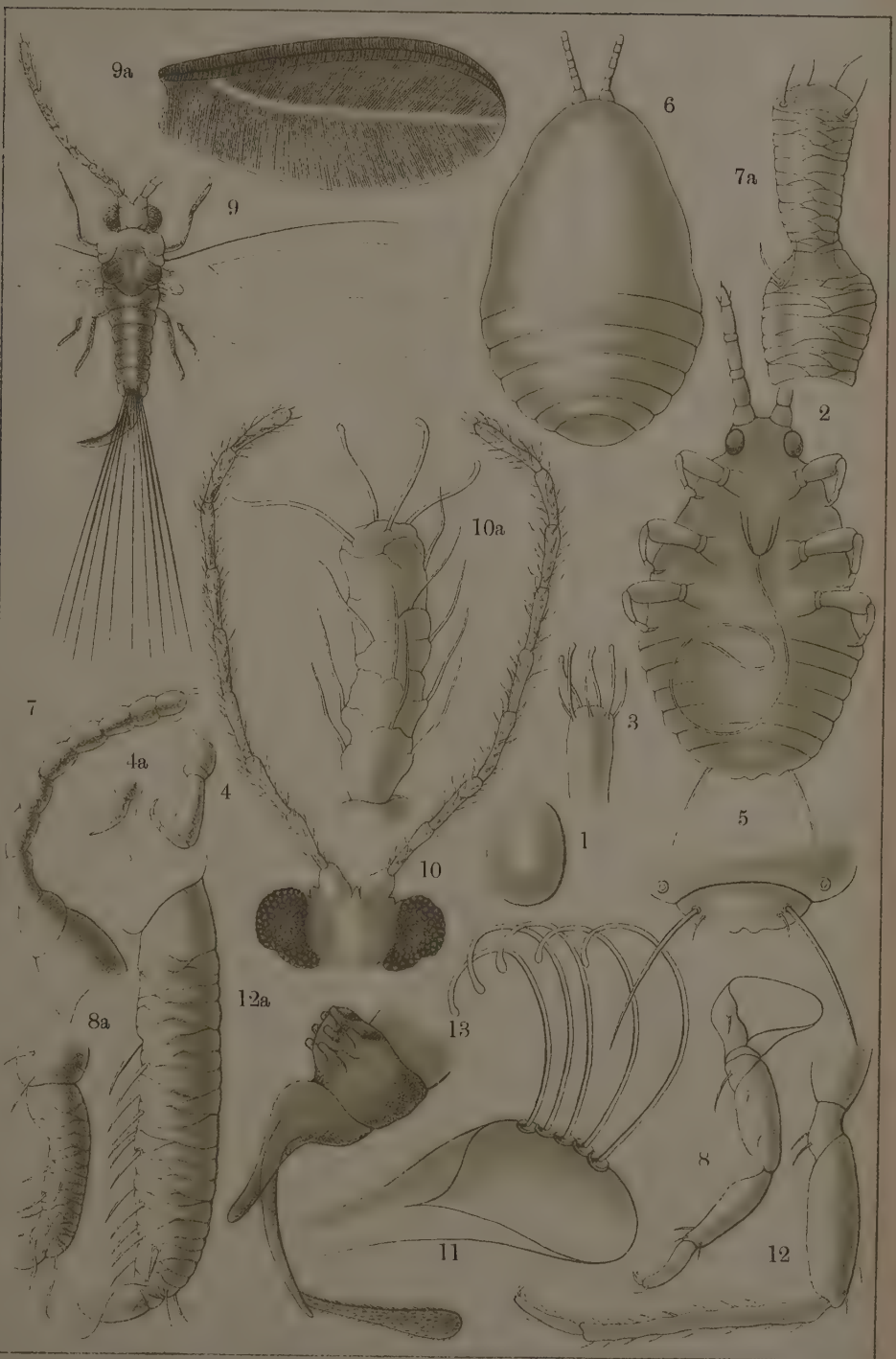
Xylococcus quercus Ehrh.

1900. Ehrh.—Candian Entomologist xxxiii, p. 311.

## EXPLANATION OF PLATE XXXIV.

XYLOCOCCUS MATSUMURAE N. Sp.

Fig. 1. Egg. (z. AA × 4).
„ 2. Newly hatched larva, ventral aspect (z. 1 × E).
„ 3. Last antennal segment of newly hatched larva (z. 2 × E).
„ 4. Leg of the same (z. 1 × D); 4a, claw of the same (z. 4 × D).
„ 5. Last abdominal segment of the same (z. 2 × D).
„ 6. Adult female (greatly enlarged).
„ 7. Antennae of the same (z. 4 × AA); 7a, (greatly enlarged).
„ 8. Leg of the same (z. 4 × AA); 8a, tarsus of the same (z. 4 × D).
„ 9. Adult male (z. 1 × AA); 9a, wing of the same (z. 1 × AA).
„ 10. Head of the same (z. 3 × AA).
„ 11. Hind wing or Haltere of the same (greatly enlarged).
„ 12. Leg of the same (z. 4 × AA); tarsus (z. 3 × E).
„ 13. Last abdominal segment of the same (z. 1 × E).




S. I. Kuwana & S. Tanaka del.

# Notes on the Life History and Morphology of Gossyperia ulmi Geoff.

BY

S. I. Kuwana.

## Introduction.*

Gossyperia ulmi Geoff, the highly injurious elm bark-louse is a member of the subfamily *Coccinae* of the *Coccidae*, or Scale insects, and is a native of Europe. It was first found in France by Signoret** who described it in 1875. It was first observed in America on the American elm (*Ulmus Americana*) in 1884, in West Chester county, New York. Again on the slippery elm (*Ulmus fulva*) at Cambridge, Mass., in 1887, where it was studied by John G. Jack. In 1888, it was found on the American elm on the grounds of the U. S. Department of Agriculture at Washington, D. C., and was studied to some extent by L. O. Haward, Entomologist of the Department.

The insect has been observed in two places west of the Mississippi River, viz at Carson city, Nevada, in 1895, and in 1894 on the campus of the Leland Stanford Jr. University near Palo Alto, Califorina.

The spreading of the insect is easily brought about by the sending of

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*The paper sets forth the result of a study of *Gossyperia ulmi* prosecuted by the writer, during the year 1899–'00, at the Leland Stanford Jr. University in California, U. S. A. At that time all the materials of study were obtained on the grounds of the University.

Since the writer returned to his native country (1902) he has learned that this insect has been discovered in the province of Shinano, and on the same kind of tree as he found it in California—an elm.

This paper is published to give in detail a description the particulars of such study. He regrets that he has been unable, because of inconvenience in obtaining materials, to study native specimens.

** Signoret, Annales de la Société Entomologique de France for 1875.

young elm trees from infested nurseries, and so the insect is liable to become, in time, a serious and wide spread pest of the elms.

All notes which have been written on the life history of *Gossyperia ulmi* and the descriptions of the various stages, leave many points untouched. It is the object of this paper to present some additional information about the insect, especially with regard to its anatomy and post embryonic development.

The post embryonic development of the *Coccidae* presents some most interesting points, the great structural divergence of the male and female being accompanied by radical differences in the post embryonic development of the two sexes.

The female undergoes an imcomplete metamorphosis, with interesting phenomena of loss of organs, while the male undergoes what may fairly be termed complete metamorphosis, with *histolysis* of certain larval organs, and *histogenesis* of imaginal organs from imaginal discs or histoblasts, processes as yet but imperfectly understood. (Diptera: a considerable study of these processes has been made in the more specialized insects like the Diptera).

## 1. General Account of the Life-history and Habits.

The elm bark-louse (*Gossyperia ulmi*) has been found upon both American and cork elm trees on Leland Stanford Jr. University campus. The trees, especialty the American elms were badly infested. This has given me an opportunity to make the following studies concerning the life history and habits of the insect.

The adult female produces a large number of young, from the beginning of June to about the middle of August. After the young have appeared the female becomes dry and dies.

The young are very minute objects, yellowish in color, and very active; as soon as they come out from the waxy cushion they crawl about on the tree. In a short time they molt and then go up to the small twigs and leaves, and are usually found on the underside of the leaves, near the middle veins; sometimes they are found on the upperside. Before the leaves fall they return to the twigs and large branches, or the trunk, otherwise they would fall to the

ground with the leaves and perish. Later in the season they are to be found in great numbers in the cracks of the bark and in the joints and around the dead scales where they have settled themselves to pass the winter.

The insects are more abundant near the middle portion of the tree, on the underside of the branches, and in sheltered places, and less on the tips or on the younger branches. The cracks in the bark of an old trunk are often full of dead insects. This insect, like other scale insects insert its long slender beak or buccle setae into the plant tissue and sucks the sap, and is one of the worst pests of the elm trees.

During the winter the larvae fasten themselves to the plants, being thinly covered with a white wax. They are inactive in cold weather, but on warm days, they may be seen crawling about. In the laboratory, they move about quite freely all winter.

The larvae reach the mature stage in the latter part of January. The first cocoons were found January 27, in the breeding cage; two days latter a number of coccons were found on the underside of the limbs of some of the infested trees. Three days after the cocoons were seen, a grayish white projection was found at one end. This was the cast off skin of the larva, which had now changed to pupa. On February 2nd. the undersides of the limbes and branches were covered with white cocoons, which, from a short distance, gave them a snow white appearance.

The pupal stage lasts from seven to ten days. The adults first appeared on February 10th. Some of them had short thick wings, others had wings which covered three or four abdominal segments, while others had long transparant wings. The body was dark reddish and the antennae and legs pale. They were very active, but none of them, not even the long winged ones, had power to fly. The short winged ones predominated. Some had two long caudal filaments, while others had none.

The females and males mature at the same time, but the females do not make cocoons; they simply cast off their old, gray, waxy skin, which splits at the dorsal line. They are quite as active as the males. After copulation takes place, they move about for a while and then settle in a crack or on the underside of the large branches. The males soon disappear. The female

remains permanently fixed to the bark, secrets honey dew, increases in size, and becomes surrounded by a white marginal ring which consists of a white waxy material secreted by the developing insect. This waxy material arches over the back of the insect to which it is finally attached and curles inwards.

When a female is taken out from the cushion it seems to be a lifeless object, like a barly grain in shape, smooth, shiny, dark reddish on the dorsal aspect, and pale on the posterior extremity, while the ventral aspect is slightly covered with white wax. When turned over the feet move feebly. The young are born during the summer months and the life cycle is complete.

The manner of copulation.—When the insects have arrived to the mature stages, which is in February and March, they are quite active, roaming about on the branches. The male mounts the back of the female with its head in the same direction, bends its back a little, and also its long, bristle-like, genital appendages, towards the caudal extremity of the abdomen of the female and at the same time the abdominal segments of the female move rapidly up and down, and copulation takes place. This is usually accomplished in about ten minutes. The male lives only a short time after copulation; the female crawls about for a while, and finally settles in the cracks of the bark, on the trunk or large branches.

### 2. Post Embryonic Development Female.

*Larva* (First stage).—The larva at birth is oval, flat, transparent, and yellowish in color; its length is about, 0.4 mm. and width about 0.15 mm.; the margin is finished with strong spines. The body consists of thirteen segments, not distincly grouped into body regions. The skin shows hexagonal marking, and there are four rows of spines on the dorsal aspects.

*Head* :—The head is so flattened that the frontal portion is completely turned under, and appears as though it were a part of the ventral aspect. The dorsal aspect is somewhat crescent-shaped, with the anterior margin regularly curved, and the posterior end broadly jointed at the thorax. There are six marginal spines, on each side, and a row of four spines between the antennae.

The eyes are situated on the margin, at the extreme outer angles of the head, just behind the antennae; and are reddish in color.

The clypus is an elongated triangle with the anterior margin straight and the sides very convex.

The antennae are composed of seven joints. The first is short and stout, the second longer but more slender, the third more than twice as long as the second and longest of all, the forth, fifth and sixth are about equal in size, the seventh longer than the sixth and tapering towards the extremity, and somewhat irregular in outline. All segments have several prominent hairs. The length of the antennae is about 0.09 mm.

The labium, or beak is triangular in form, and consist of two segments. The sides of the labium are turned upward and inward, becoming almost united at the dorsal aspect so as to form a flattened conical sheath through which the buccal setae are thrust. The free tapering end is finished with a few spiny hairs. The buccal setae are four in number, enlarged at the basal end, and more than twice as long as the whole length of the body.

The chitinous framework of the mouth-parts in this stage shows a more prominent condition than in the adult female; the essential parts are the same, but in the adult female they are more strongly chitinized.

*Thorax* :—The thorax is very large, being the widest part of the body, and occupies more than one third of the entire length of the insect. The prothorax is smaller than the mesothorax, narrowing at the anterior end up to the head. The suture between the head and prothorax is indistinct but there is a slight constriction. There are three strong marginal spines on each side, and four on the dorsal aspects, the two middle ones being larger than the outer two.

The mesothorax is the largest segment of the thorax, wider than long, tapering slightly at both ends, with three marginal spines and four dorsal spines as in the prothorax.

The metathorax is smaller than the mesothorax, but larger than the prothorax, two marginal spines on each side, and four dorsal spines as in the mesothorax.

The legs are attached near the lateral margin of the thoracic segments.

They are equal in size and similar in structure, being rather stout and short. The coxa is large, and thick, a little longer than wide; the trachanter is a small triangular piece so closely united with the femur that it appears to be a part of the latter; the femur is the largest segment, wider than the tibia, tapering at both extremities; the tibia is less than one half the length of the femur and more slender; the tarsus consists of a single segment longer than the tibia, tapering toward the free end, and bears a pointed claw and four knobbed hairs.

The spiracles are four in number and simple. The anterior pair are situated on the ventral aspect of the prothorax, a short distance from the front legs; the second pair are located between mesothorax and metathorax. They are surrounded by a kidney shaped chitinous piece.

*Abdomen* :—The abdomen is composed of nine segments, tapering toward the free end; the first eight segments are alike except in size, the last or ninth is greatly modified being prolonged backwards at the sides; the posterior margin bears two long filaments and a few spines. Each abdominal segment has a strong marginal spine on each side and four on the dorsal aspect. The middle spines of the dorsal aspect on the first three abdominal segments are large and the others small. The spines on the side are small and all of the same size. The anal opening is provided with six hairs.

*Larva* (Second Stage).—After the first molt, the larvae become more or less oval in shape, with very distinct segments. The marginal and dorsal spines are lost, and the dorsal aspect is now covered with rather short spines, while the ventral aspect has a few small hairs. The length of the body is about 1 mm. width about 0.5 mm. across the thorax, and is dark reddish in color. The dorsal aspect is now furnished with wax ducts. The spines are about 0.03 mm. in length, yellowish in color, and covered with white wax. The legs and antennae show no apparent changes, except in size. The length of the antennae is about 0.14 mm.

When ready to molt again the length of the body is about 2 mm. and half as much in width at the thorax. Antennae is about 0.8 mm. in length and seven jointed. Up to this period the sexes resemble each other so closely in every respect that they are hardly distinguishable.

L. O. Howard says* that the antenna of the newly hatched larva is six jointed, and of the full grown male larva is seven jointed, while the antenna of the full grown female is six segmented. It would seem by this that the different sexes can be distinguished by the characteristics of the antennae. According to my observation all stages have seven jointed antennae. Only in a few cases the antennae were six jointed.

*Adult* (Third Stage).—The adult female is oval, wingless, and spiny, and resembles, in general appearance, the immature stages. The body is about 1.5 mm. in length, and 0.6 mm. in width, color dark brown. Antennae and legs are somewhat faded. The cast off skin is grayish white.

After impregnation the body becomes very much enlarged and more rounded. Length of the body is than about 2.5 mm. width about 1.6 mm. The head and thorax together are about equal to one-half of the entire length of the insect, and the thoracic region is the widest. The structure of the head and its several points are not different from the larval condition. The mouth parts are about the same, but more chitinized. The antennae are about 0.25 mm. to 0.30 mm. in length, and consists of seven segments; the third and fourth are longest, the fifth and sixth shortest the seventh shorter than the fourth but almost as long as the fifth and sixth together. Each segment has a few prominent hairs. The hairs on the first segment are the shortest; the seventh has the longest hairs. The three pair of legs are similar in structure. They are slender and comparatively short. The abdomen occupies about half of the entire length of the body, tapering toward the posterior extremity. The ninth segment is modified by being prolonged at the sides backward, bearing a few spines and a long spiny hair at the extremity. The anal opening has six hairs.

### Male.

*Larva* (First and Second Stages).—The male in the first and second stages is like the female in the same stage.

*Cocoon of male.*—When the male larvae are full-grown each finds a suitable place and makes a cocoon. The cocoons are found in groups, usual-

* Insect Life Vol. II., P. 36, 1889.

ly on stems or branches, and are particularly numerous near the stem or on the underside, where they are protected from sunshine and storms.

These cocoons give the branches a snow-white appearance, in patches of variable size. Some cocoons have a projecting mass at one end and some do not. This projecting mass is the cast off skin of the larva which is pushed out from the posterior end of the cocoon during pupation. In some cases this skin is left inside of the hinder part of the cocoon.

*Development of the pupa.*—Differing markedly from the female, the male undergoes, between its larval and adult stages, a distinct pupal stage; a stage wholly comparable to the pupal stage of insects with complete metamorphosis. There is a considerable breaking down or histolisis of larval organs and tissues, and a building up or histogenesis of imaginal organs from imaginal discs. The larval legs are replaced by imaginal legs which are wholly new organs and which begin their development (As imaginal discs in the body) during the larval life, and so with the other organs.

On examination of the male larva, just before the change takes place to pupa, (Fig. 1) no larval organs can be found, the body, except the head and thorax, being nothing more than a sack containing protoplasmic granules, and oil drops in a yellowish fluid. In the head and thorax there are five pairs of granular masses of cells in the ventral aspect, and a pair on the side of the mesothorax. These are the imaginal discs or buds (Fig. 1; img) from which new appendages develop. The pair of buds in the head, which form the eyes (Fig. 1, img 2), are larger, the other pair give rise to the antennae (Fig. 1; img 1); three pairs on the thorax, one on each segment, develops into legs (Fig. 1; img 3), one on each side of mesothorax, develops into wings (Fig. 1; img 4).

In studying these discs by means of sections, it is seen that these imaginal discs are made up of microscopic masses of indifferent cells which rise from the hypodermis during the larval growth.

The imaginal discs are gradually developed into elongated bodies, the wings discs extending beyond the body. About this time the pupa casts the last larval skin and pushes it out from the cocoon. This is "propupa stage" (Fig. 2) according to Prof. Riely. The propupa develops gradually,

the antennae and the legs become more elongated and divided into two parts, the wing pads more flattened (Fig. 3); and finally the antennae and legs become more slender, the antennae dividing into ten segments, the legs into five, and the dark eye spots appearing (Figs. 4, 5).

*Pupa* (Third stage).—Color of pupa is a blackish red, legs, antennae, and wing pads are pale and transparent; the eyes dark. The general shape is an elongated oval, resembling the larva. The antennae are pressed close to the side, reaching to the base of the wing pads. The wing pads are also pressed against the sides; they are elongated, and ovate in form, reaching to the second abdominal segment; the legs are short and rather stout; the first pair are thrust forward, while the other pairs extend downward. The abdominal segments are distinct, the anal end is pointed.

*Adult* or *Imago* (Fourth stage).—Up to the present time, it has not been made clear whether there are two kinds of males developed from different sorts of eggs, or whether the perfect males are those in which aditional development and molting have occurred, or whethere the varying males are developed from the same sort of eggs and vary among themselves. Dr. Howard* thinks that there may have been a molt between the "Pseudoimago" (the short winged form) and the perfect male, for by no other way can we account for the difference in form. Prof. G. H. Perkins** thinks there is no molt between these two forms of males, but considers it probable that some differences in food, season, and climate effect the development of the insects; and that under some conditions imperfect males predominate, while under other conditions the perfect ones are more abundant. To investigate the matter, I kept some cocoons in a breeding cage. On February 10th. came out four specimens, three with short wings and one with long; the next day, there came out three with long and nine with small wings, varying from medium to short; the next day a great many emerged, those with short winged predominating. I separated them according to the difference in the size of the wing. They lived from two to three days, but I saw no signs of another molting. All of these different forms of males copulated freely.

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Vol. I. P. 38, 1889.

** Eleventh Vermont Agricultural Report, P. 269, 1889-'90.

An examination of the short wing showed them to be thick, wrinkled and somewhat pale yellowish in color; those of medium size were thinner, not so wrinkled but still not perfect, while the wings of the perfect male were a little longer than the body, and very thin and transparent. Many of the short winged forms have no waxy filaments extending from the posterior end of the body, and then again many do, just as in the perfect males. Those without waxy filaments may possibly have lost them through breaking, or other causes. This experiment seems to show that Prof. Perkins' idea may be correct, that the difference in the males is caused by food, season, climate, or other circumstances which cannot be explained.

The body of the male is oval, flat, and stout, and very fleshy; 1.5 mm. in length, 0.35 mm. in width at the thoracic region. 2.6 mm. when wings are expanded; dark reddish in color; antennae and legs a pale yellow; wings transparent.

*Head :*—The head is nearly globular in form, slightly pointed in front. 0.15 mm. in length, 0.18 mm. in width. The cheeks are very large and globular forming the larger part of the head. There are a few short spiny hairs on the frontal region. Mouth parts are wanting.

The antennae are ten jointed, 0.5 mm. in length. The first segment is the shortest and is thick; the second large and globular; the third the longest; while the rest are equal in size; except the tenth, which tapers toward the apex. All segments are finished with long fine hairs.

The eyes are globular, prominent, and six in number. Two are on the dorsal aspect near the frontal margin, rather small and transparent, the two pairs on the ventral aspect are large and dark reddish in color.

*Thorax :*—The thorax is large and somewhat oblong; three thoracic segments are distinct. The prothorax is small and somewhat triangler in shape, much broader than long, and convex on the dorsal aspect, while the ventral aspect is rather flat. The mesothorax is the largest, somewhat angular in front and rounded at the posterior end. Sectulum and scutellum are distinct; former is very much broader than long, the latter is as long as wide and is convex, and triangular in shape. The muscles in this region are well developed. The metathorax is smaller than the mesothorax, but longer

than the prothorax. It is such wider than long, and is closely attached to the posterior end of the mesothorax.

The wings are thin and membranous; when folded on top of the body they are as long or longer than the entire length of the abdomen, with very minute hairs. The front margin is thick and nearly straight, except for a slight curve toward the free end; the posterior margin is curved very strongly. They are provided with two veins, subcastal and cubital; the former is longer and stronger than the latter, running parallel with the costal margin and disappearing gradually toward the external margin of the wings. The cubital is shorter and weaker and rises near the base of the subcostal, running abliquely, terminating about midway of the posterior margin.

The balancers are composed of two parts, a basalbristle, and a free end slightly curved.

The legs are long and slender and similar in size and structure. The coxa is large and stout, oval in shape; the trachanter is very short and small, closely attached to the femur, and is oblong in shape; the femur is long and stout; the tibia is long and slender, longer thah the femur and trachanter combined, with two strong spines on the inner portion of the posterior end; the tarsus is about one fourth the length of the tibia, slightly tapering toward the extremity where it is terminated by a stout, movable, denticulated claw, and four knobbed hairs; two long ones are attached to the outside of the tarsus, a short distance from the extrimity, and two smaller ones to the base of the claw. Both extend a short distance beyond the tip of the claw.

*Abdomen:*—The abdomen is a little longer, but narrower than the thorax. It consists of nine segments; the first seven segments are similar in form, gradually tapering toward the free end. The eighth segment is modified slightly by being prolonged at the sides, backward. The dorsal aspect on each side is provided with a group of spinnerets. Two long spiny hairs project from the middle of each group, through which, the long waxy filament is sent out. In the ninth segment is found the penis, which consists of two long bristle-like appendages lying closely side by side so as to form a single long filament, which is placed in slender conical style.

## 3. Anatomy.

The anatomy of a number of the species of *coccidæ* has been studied and described. (See the papers of List,[1] Mark,[2] Pulnam[3] and etc.)

The essential features of the anatomy seem to be the same in the different groups, but there is difference in detail of structure.

I have studied in some detail the anatomy of *Gossyparia ulmi*, chiefly using specimens in the second larval stage, as the thin body wall of this stage is more pervious to killing fluids than the thicker integument of the adult. Of the adult I have only attempted to describe the sexual organs and to refer briefly to other important points.

*The chitinous framework of the mouth parts*:—The pharynx and bases of the mouth parts are conbined in a space between two somewhat five-sided planes, supported by a chitinous framework (Fig. 6). The lower plane, or *area inferior* of Mark, is large ; it is bounded on the front by the *arcus inferior*, on the side by the *castae inferiors*, right and left, which appears to be compased of two parts (Fig. 6; b, n.), meeting at pint F. The posterior portion meets with the corresponding part of the *castae superiors* to form the perforated clavus through which the buccal setae pass (Fig. 6; p.). The upper plane or *area superior* is bounded by the *castae superiors* right and left (Fig. 6; C.M.) which bend backward and downward to meet the *castae inferiors* at e. The posterior portions of the *castae superiors* (Fig. 6; m.) bend downward until they unite with a broad plate which unites with the *castae inferiors* to form the clovus. At point f. and g. a branch d connects the *castae superiors* and *inferiors*.

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1). Joseph H. List.—Orthezia cataphracta show.
Zeitschrift f. Miss. Zoologie Bt. XIV.

2). E. L. Mark.—Berträge zue Anatomie and Hislologie der Pflanzenlause, irsbesondere der Coccidan.
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3). J. D. Putnam.—Biological and other notes on Coccidae.
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Adolfo Targioni Tozzetti.—Studii Sulle Cocciniglie.
Societa Italiana di Scienze Naturali, Tomo. III, N. 3, 1867.

From the middle of this branch, a chitinous process (Fig. 6 ; t.) extends inwards about two-fifths of the distance toward the center, and unites with an internal tube (Fig. 6 ; nt.) and helps to support it. The enlarged conical bases of the four buccal setae (Fig. 6 ; st.) are supported by this complicated framework. Each seta consists of a very long, slender, solid rod, or so called "tube," enlarged at the base, forming an elongated cone. The conical base is attached to the framework by strong muscles. In the lower pair of setae the cones are more elongated and more slender, while the upper ones are rapidly enlarged at the bases. The four setae meet at the clavus (Fig. 6 ; p.) and pass through it, forming a tube. This tube then passes into a long, pocket called the labial cavity, which lies in the body cavity (Fig. 7 ; la,C.) beneath the nervous system, and extends as far as the fourth or fifth abdominal segment. The tube fills the full length of this pocket and returns to where it entered, forming a long loop.

When in use, the tube is thrust through the labium. The internal part of the labium (Fig. 7 ; el, s.) seems to be modified to form a thin, transparent, elastic sack, through which the setae pass when in use. The setae are withdrawn by means of the elastic nature of the walls of the pocket. The pocket appears to be free in the cavity. Its walls (Fig. 8) consist of three layers, an outer thin layer (Fig. 8 ; au, l.), a thick middle layer (Fig. 8 ; mi, l.), and an inner layer (Fig. 8 ; in, l.) which is a weakly chitinzed membrane.

The buccal setae are furrowed their entire length, but are not hollow, as former writers have observed.[1] They meet at the clavus to form a tube through which the sap of the plant is sucked up. Between the setae is a trumpet shaped, strong, chitinious tube (Fig, 6 ; nt.), which opens at the juncture of the four setae. This internal tube protects the buccal cavity and anterior part of the pharyx.

*Alimentary Canal :*—The alimentary canal begains as a narrow buccal cavity extending upward and widening to form the pharynx. The pharynx

1). Maskell.—An. account of New Zealand Scale-Insects, p. 9.
J. D. Putnam.—Proceeding of the Darenport Acd. N. S. Vol. II, p. 318.

is large and long with very thick wall; the posterior end being gradually narrowed and merged into the oesophagus (Fig. 9, oe.). The oesophagus is long and slender and extends slightly forward from the posterior end of the pharynx, then turned upward, passing outside of and around the *arcus superior*, and then backward extending into the thorax, there it becomes enlarged and is merged in the ventriculus (Fig.9.ve). The ventriculus extends backward a short distance and then turns abruptly forward making a few convolutions enclosed within the anterior part of the rectum (an extraordinary condition common to all of the *Coccidæ* so far studied), and forms a very long and narrow intestine (Fig. 9; in.) extending backward nearly as far as the anus, and then forward to near the point of beginning where it joins the rectum. The rectum (Fig. 9; ri) is a long straight tube distended in the middle which extends backward from the posterior end of the intestine to the end of the anal opening.

*Malpighian tubes:*—A short distance from where the large intestine emerges from the anterior part of the rectum, arise the two Malpighian vessels (Fig. 9; mp.). They are fused at their bases to form a single tube which soon devides into two long tubes extending one on each side of the rectum.

*Salivary glands:*—There is single pair of salivary glands (Fig. 11; sa, g; 13), one gland laying on each side of the oesophagus. Each gland consists of a number of spherical lobes (Fig. 13; la.), more or less united. Each lobe consists of one or more nucleated cells, and each lobe gives rise to a small tube which unites with a larger one. This large tube unites with the one from the other side to form a common duct which opens into the mouth.

*Wax secreting glands of larva and adult female:*—The wax is secreted by minute spherical glands (Fig. 14) which are distributed on the dorsal aspect of the body (Figs. 11, 12; wg.) usually six to eight in each segment. Each gland consists of several nucleated cells with a slender straight tube or pore (Fig. 14; po.) which opens externally. This tube is chitinized, transparent, and enlarged at base where it rises from the gland.

*Wax gland of adult male:*—Two large ovel shaped wax glands are situated in the seventh and eighth abdominal segments of the adult male

(Figs. 15, 15a), one on each side of the alimentary canal. These glands furnish the material forming the long waxy filament.

*Respiratory organs* :—The spiracles are four in number as already described in the account of the extenal anatomy. These extend inward from each spiracle, a large tracheal tube (Fig. 16) which soon divides into many branches and subbranches, sending its ramifications to all parts of the body. There arise immediately the anterior spiracles two main branches and three small ones. One large branch extends toward the opposite side of the body, close to the ventral wall until it meets and unites with a corresponding branch from the opposite spiracle. The other large branch extends longitudinally toward the posterior end close to the ventral wall until it meets with a similar one from the posterior spiracle on the same side. A small branch extends to the antennae, while two others run forward into the head. From the posterior spiracles there extend five tracheal branches ; one running forward to meet a similar branch from the anterior spiracle ; another runs close to the ventral wall towards the opposite side to meet with a corresponding branch from the opposite spiracle ; two other extend toward the posterior end, each giving out several branches which lie free in the abdomen ; the fifth branch is smaller than the others, and extends laterally.

*Nervous system* :—The fusion of the nervous system (Fig. 17) is carried to such an extreme that there are but two large ganglia, one in the head and the other in the thoracic region. The supraoesophageal ganglion, or the cephalic ganglion (Fig. 17 ; s. o. g.) consists of two lobes which lie immediately in front of the mouth parts. From the anterior region of the cephalic ganglion proceed two large optic nerves (Fig. 17 ; op. n.) to the eyes ; from the underside extend two small nerves to the antennae (Fig. 17 ; an. n.). From the posterior end is sent two commissures (Fig. 17 ; com.) backward, allowing the oesophagus to pass upward between them (Fig. 17 ; oes.) ; then they unite into one, passing between the *arcus superior* and *arcus inferior* and thence into the thorax. Here is situated the large, elongated thoracic ganglion (Fig. 17 ; tho. g.), tapering at each end. A longitudinal section (Fig. 17) shows that it consists of five ganglia fused

together. The cross section plainly shows a longitudinal division (Fig. 17 b). This single large thoracic ganglionic mass is composed of the fused suboesophageal ganglion (Fig. 17; in. o. g.), the three thoracic ganglia (Fig. 17; g. 1, 2, 3), and the most anterior abdominal ganglion (Fig. 17; a, b, g.). Each thoracic ganglion sends off a pair of branches, one from each side, which innervate the legs (Fig. 17; l. n.) Two large nerve cards extend from the posterior end of the abdominal ganglion, each of these sending of two branches outward and backward, free in the abdomen.

*The circulatory system or Heart :*—I have seen no traces of a dorsal vessel or heart.

*Muscular system :*—The muscular system consists of numerous distinct straight fibres (Fig. 18 b), which remain separate from each other. The muscles of the thoracic region (Fig. 18) are very much complicated, while in the abdomen, there are two sheets of muscles, one on the dorsal aspect, and the other on the ventral aspect of the body. The dorsal sheet is made up of six bundles, three on each side of the middle line of the body, and there are seven bundles in the ventral sheet. They are paralled to each other and jointed at each segment.

*Reproductive organs of larva :*—In the young female larva the reproductive organs (Fig. 19) are two large, elongated ovaries (Fig. 19; ov.), situated one on each side of the abdominal cavity. From the posterior end of each of these extend two oviducts (Fig. 19; ovd.) about equal in diameter to the ovaries, which unite into a common duct (Fig. 19; c. ovd).

*The reproductive organs of the male larva* have not yet been examined.

*Reproductive organs of the adult female :*—The ovaries (Fig. 20) of the adult female are two in number. Each consists of many oval shaped, bulb-like ovarial tubes (Fig. 20; o. v. t.), each of which opens into the oviduct by a short broad tube. The oviducts (Fig. 20; ovd.) become united to form a common oviduct (Fig. 20; c. ovd.) which ends at the vagina (Fig 20; va). The spermatheca is a large sac-like organ which arises from the common oviduct near the vagina (Fig. 20 b, spe.).

*Reproductive organs of the adult male :*—The reproductive organs of the adult male consist of two large oval shaped testes (Fig. 21; ts.)

tapering at each end, which are situated in the fifth and sixth abdominal segments, one on each side of the alimentary canal. The vas deferens arises from the posterior end of the testes (Fig. 21; vas.). They unite to form a common duct—the ejaculatory duct (Fig. 21; eja.). The terminal portion of the ejaculatory duct is covered with a strong chitinous membrane, forming the penis, or intromittent organ. The lower end of the seminal ducts are slightly enlarged to form the seminal vesicle (Fig. 21; sev.).

*Spermatozoa* :—The spermatozoa (Fig. 21 a) are long and thread-like, slightly enlarged at one end, about 0.32 mm. in length and are grouped into bundles.

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## EXPLANATION OF PLATES.

### Plate XXXV.

Fig. 1. Male larva, just before change to propupa.
img ; imaginal descs ; $img^1$, antennae ; $img^2$, eye ; $img^3$, leg ; $img^4$, wing ; l.s, larval skin ; lg, larval leg ; la, larval antenna.

Fig. 2. Pupa (or propupa).
an, antenna ; e, eye ; w, wing ; $l^{1,2,3.}$, legs.

Fig. 3. The same with Fig. 2, more advanced stage.

Fig. 4. Pupa, nearly full grown, showing the internal structure.

Fig. 5. Pupa, longitudinal section ; 5a, cross section, na, nervous system ; img. l, imaginal desc of leg ; img. w, imaginal desc of wing ; img. a, imaginal desc of antenna.

Fig. 6. Mouth parts and chitinious framework supporting them. a, aceus inferior ; s, aceus superior, b.n. casta inferior ; c.m. casta superior ; d, a branch which connecting the castae superiores and inferiores ; st, buccal seta ; t, a chitinous process ; nt, internal tube.

Fig. 7. Longitudinal section of mouth-parts of larva and labial cavity with buccal setae.
mm, muscles of mouth parts ; la. c, labial covity ; el.s, elastic sack of labium ; la, labium.

Fig. 8. Cross section of labial cavity.
st, buccal setae ; au. l, auter layer, mi.l, middle layer ; in. l, inner layer.

Fig. 9. Alimentary canal.
oe, oesophagus ; ve, ventriculus ; ri, rectum ; in, intestine ; mp. Malpighian tube.

Fig. 10. Diagram of the ventriculus, showing the convolution.

Fig. 11. Longitudinal section of larva, (second stage) ; Fig. 12, Cross section of thoracic region ; Fig. 12 a, Cross section of abdominal region.
sp, spine ; ep, epidermis ; hyp, hypodermis ; sa. g, salivary gland ; w.g, wax gland ; oes, oesophagus ; ve, ventriculus ;

r, rectum; re, reproductive organ; mp. Malpighian tube; n, nervous; z, leucocytes; f, fat bodies; mu, muscles.

## Plate XXXVI.

Fig. 13. Salivary gland of larva.
la, one of the lobes; n, nuclea.

Fig. 14. Wax gland of larva.
ep, epidermis; po, pore of wax gland; Hyp, hypodermis; wg, wax gland, n, nuclea.

Fig. 15; Fig. 15 a. Wax gland of male.
spi, spinnerets; w,g, wax duct; sp. spine; re, reproductive organ.

Fig. 16. Respiratory system of larva.
tr, trachea; sp, spiracle.

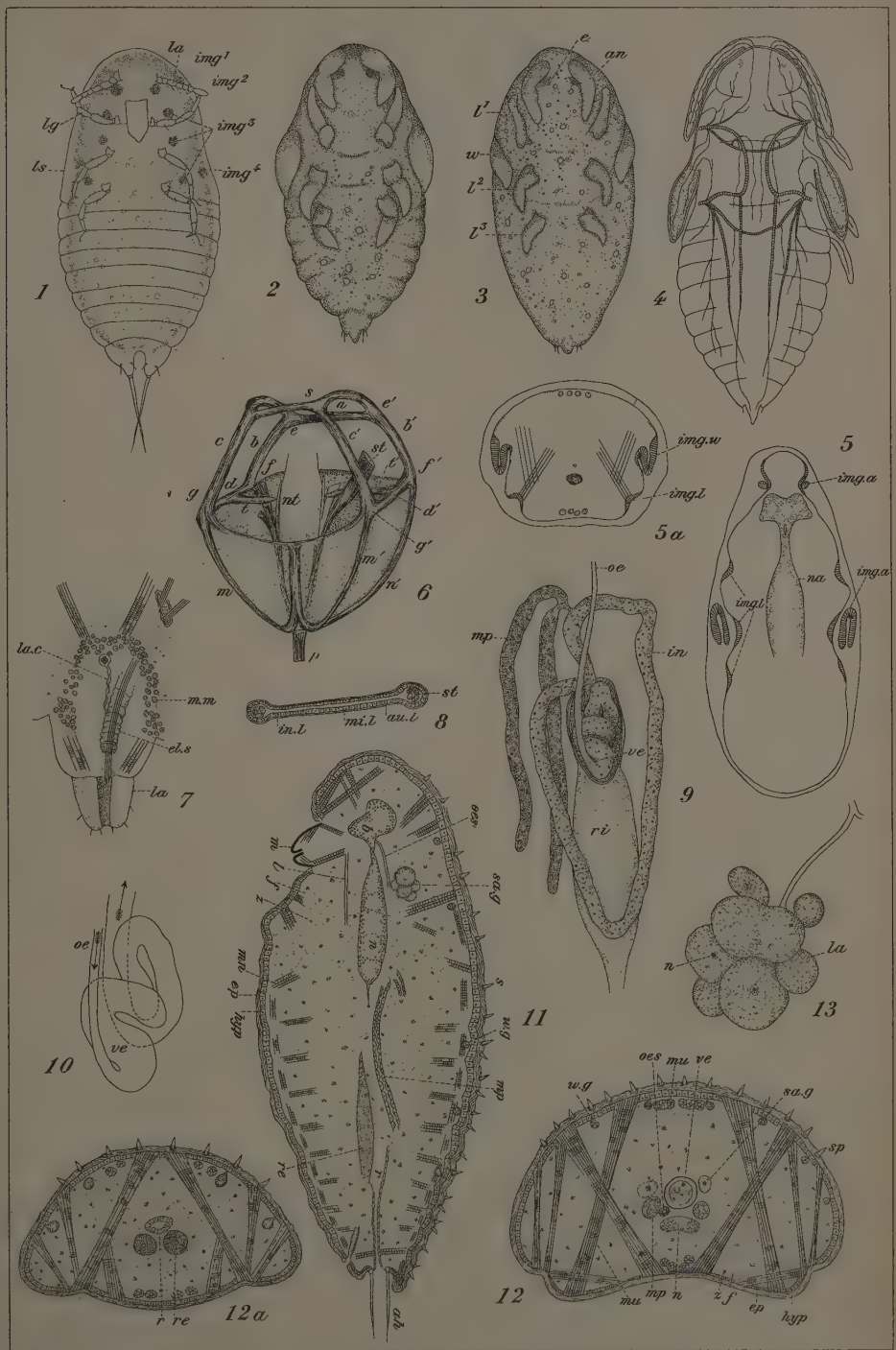
Fig. 17. Nervous system: 17, Horizontal section; 17a, Longitudinal section, 17b, Cross section of brain, 17c, Horizontal section of brain.
s.o. g, supraoesophageal ganglion; sp, n, opitic nerves; an. n. antennal nerves; com; commissures; oes, oesphagus; in, o, g, infra oesophageal ganglion; g.$^{1,2,3}$, thoracic ganglion; ab. g, abdominal ganglion; cor. ganglion cell; in, nerves fiber.

Fig. 18. Muscle system of thoracic region of larva; Fig. 18a, Muscle of leg; Fig. 18b. Bundles of muscles showing the striae.

Fig. 19. Reproductive organ of larva; Fig. 19a, Part of ovary, showing somewhat hexagonal cells.
ov, ovary; ovd, oviduct; c. ovd, common oviduct.

Fig. 20. Female reproductive organ; Fig. 20a, Wall of common oviduct; Fig, 20b, spe. Spermatheca.
ov, ovary; o.v.t, ovarian tube; ovd, oviduct; c. ovd, common oviduct; va, vagina.

Fig. 21. Male reproductive organ; Fig. 21a, Spermatozoa. ts, testes; eja, ejaculartory duct; sev. seminal vesecle; sp, spermatozoa; vas, vas deferens.

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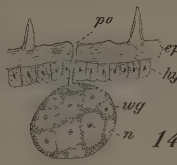


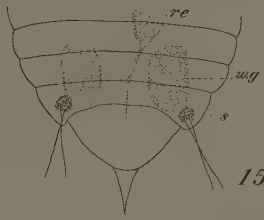

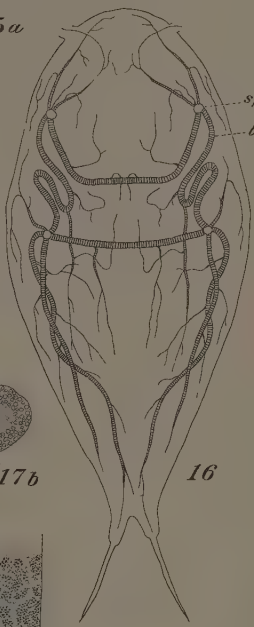


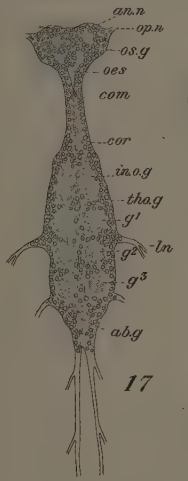


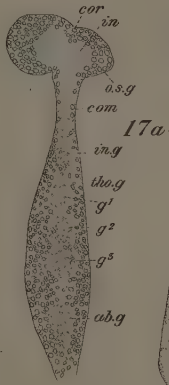


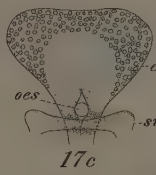


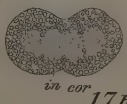


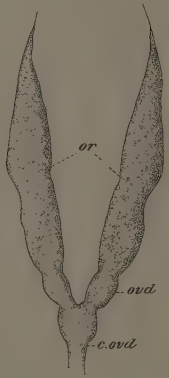


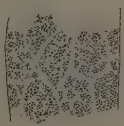


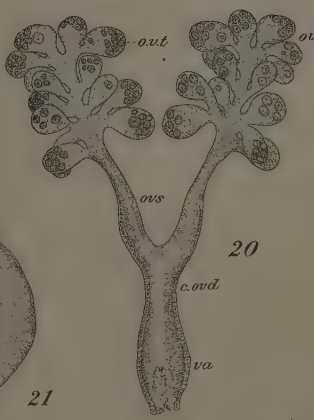


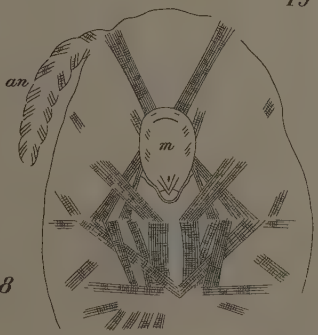


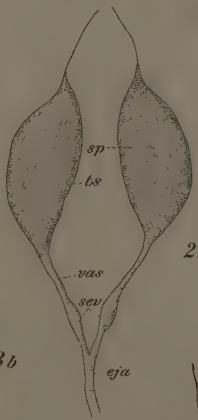

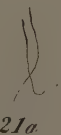

S. I. Kuwana del.

明治四十年十月廿七日印刷
明治四十年十月三十日發行
明治四十一年二月二十日再版印刷
明治四十一年二月廿三日再版發行

# 農事試驗場

東京市日本橋區兜町二番地
印刷者　金澤求也
東京市日本橋區兜町二番地
印刷所　東京印刷株式會社

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